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THE UNIVERSITY OF ALBERTA

TEACHER RESOURCE MODULE:
ROBOTICS

BY

RAY A. CIMOLINI

A THESIS

SUBMITTED TO THE FACULTY OF GRADUATE STUDIES AND RESEARCH

IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE

OF MASTER OF EDUCATION

IN

INDUSTRIAL ARTS EDUCATION

DEPARTMENT OF INDUSTRIAL AND VOCATIONAL EDUCATION

EDMONTON, ALBERTA
FALL, 1988

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The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies and Research, for acceptance, a thesis entitled, TEACHER RESOURCE MODULE: ROBOTICS, submitted by Ray A. Cimolini, in partial fulfillment of the requirements for the degree of Master of Education.

Supervisor

Peter Wright

Roger W. Toogood

Date Sept 23/88

DEDICATION

This thesis is dedicated to **Dr. C. H. Preitz**. A selfless and accomplished educator who inexhaustibly devotes his time and expertise to the professional growth of both students and colleagues throughout all faculties of the University of Alberta and within countless professional organizations.

ABSTRACT

The primary purpose of this study was to identify and organize the instructional content for a module and its units of instruction on robotics. The module that resulted from this study was one that could be integrated into the elective strand of the Computer Processing 10-20-30 curriculum guide, with robot topics as content organizers for units of instruction that a teacher could use to teach the instructional content to grade 10, 11, or 12 students.

The supervisors for either industrial education, industrial arts, or technical education from each state of the United States and from each province of Canada were requested to supply the researcher with the names and addresses of secondary school teachers in their jurisdiction who offered either a course or a portion of a course in robotics. Course materials in the form of course guides, course outlines, and a curriculum guide were received and reviewed by the researcher to identify structure, scope and sequence as well as to determine commonality of content. These materials were also reviewed to identify performance objectives and the method of delivering content to the learner. A charting procedure was designed and used in making this analysis and review. The information that was obtained from the analysis helped to provide the researcher with perceptions and guidance in formulating and organizing the suggested robotics module and its units of instruction.

A list of ten professional personnel who were responsible for teaching a course in robotics at the tertiary school level were selected and invited to serve as members of the Panel of Experts. It was the responsibility of the Panel to review the suggested module and its units of instruction and to recommend changes they thought relevant and significant.

From the results of the review of the Panel the module and its units of instruction were revised and modified using the recommendations and criticism

received from the Panel. The results of this effort were then considered as the recommended module and its units of instruction for the Computer Processing 10-20-30 course of study.

From the research summary, findings, observations and recommendations were made.

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Last, but certainly not least, the author wishes to express his love and gratitude to his family: **Michael, Jonah, Emily, Mom, and Dad** for all of their support, patience, encouragement, and love.

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CHAPTER I

The Problem

Introduction

With the advent of the industrial revolution when machine power began to replace both human and animal power the industrial sector of the economy has looked for new ways to increase productivity of the work force and to rely less and less on these two forms of power. In the last quarter of the 20th century the most recent innovation to be implemented by industry has been the industrial robot.

Schwarz (1981), defines an industrial robot as:

> A programmable machine which is designed to move an end-of-arm tool, gripper, and/or sensor to a precise point in the work environment by a given sequence of motions and in so doing accomplishes work such as moving parts, assembling systems, and/or performing inspections on a repetitive basis without human intervention. (p. 18)

Since being introduced into the industrial environment, in 1961, robots have been continually redesigned so that they are more able to imitate the anatomical movements of a human being.

By the standards of 1987, robots that were introduced into a production cycle seven years earlier could be considered analogous to a model "T" Ford. These robots and their predecessors were unsophisticated, limited in their functions, and referred to in the industry as bang-bang or dumb machines. These machines were generally immobile, they lacked any visual or tactile sensory perception, and could not be adapted to their environment. (Hunt & Hunt, 1983, p. 8) As a result of considerable research and development in industry, in science, and in technology, industrial robots are becoming more sophisticated in their movements and in their ability to interact with their environment using visual and tactile sensors.

A research investigation was conducted by the University of Michigan (1985) with over 250 participants selected from a wide spectrum of manufacturers, retailers, and users of robots throughout the United States. The results of this research indicated that by the year 1990 there would be approximately 40,000 application robots in industrial use in the United States. By 1995, that census would increase to approximately 90,000 application robots. (p. 167) This study also projected that dollar sales for domestic robot sales in the United States would show an exponential increase between 1984 and 1995. Over this eleven year period the sale of robots would increase to 637 million dollars from 240 million dollars.

In peripheral industries, and industries that employ robots, such as computer integrated manufacturing (CIM) industries, the sales of robots during this same eleven year period would increase to 2.06 billion from 471 million dollars. (p. 18)

The automotive industry in 1985 was the leading user of industrial robots. However, other industries such as electronics and precision equipment manufacturers began to accelerate their rate of purchasing robots.

In the future it is forecast that industrial robots will change in appearance, improve in accuracy, and become available in abundant variety. The Michigan study contradicts the misconception that the implementation of industrial robots would displace workers. The results of that research show instead of robots displacing workers they would create a total of more than 44,500 jobs by 1995. (p. 75)

Cetron and Appel (1984) in Jobs of the Future predicted a much higher figure when they wrote " by the year 1990 the country [United States] is expected to need about 160,000 robot technicians" (p. 11). These technicians would be required to service the growing number of robots that would be found in industry and offices of the future. These robots when put in place will preform thousands of new tasks that will replace the hand and upper arm strength that were required of the old factory hand. (Cetron & Appel, 1984, p. 16)

The use of robots and robotic technology in the industrial sector is proving to be both incremental and evolutionary rather than exponential and revolutionary as some writers predicted, notably authors such as Asimov (1985), Engelberger (1980), and Ullrich (1983). The increase in automation of production through robotics and computerization is forecast to create a need for a more highly trained labour force. Low level entry jobs that require no training or no experience will become increasingly rare. It is predicted that this will result in a decrease in the high school drop-out rate. As a result of this phenomenon it is anticipated that more young people will be expected to enter the work force after they have completed technical training. (University of Michigan, 1985, p. 10)

Parallel to the development and implementation of robotics in an industrial setting has been that of microcomputers in the educational environment. The latter has received considerable attention from Alberta Education. According to research completed by Petruk (1986), Alberta had a census of 22,752 microcomputers in all 1,489 Alberta Schools. (p. 1) It is evident that research has been conducted on the number of microcomputers in schools and their utilization in an educational setting, but no researcher or agency in the province has attempted to determine if robotics is being taught or the population of robots in the schools of the province.

However, curriculum designed for secondary schools in Alberta in 1987 totally ignored the fact that students who were then enrolled in grade one would at the turn of the century enter a world of work where robots may be a major segment of the work force. Robots in that work force will perform operations that are repetitive, hazardous, and work in an environment that is dangerous. It has been predicted that within the next decade the development of a "smart" robot will result from research and development of the larger corporations. Unless Alberta students are prepared for this reality they will be ill-prepared to enter the world of work in the year 2000.

In the 1987 edition of the Business Education Curriculum Guide, Computer Processing 10-20-30, approved by the Curriculum Branch of Alberta Education, there are 18 modules of content. Of these, only one module is classified as mandatory core. The remaining 17 modules are elective. (p. 17) The curriculum guide for the core module includes under the topic of Issues and Trends the term "robotics" but fails to detail what should be taught by the teacher for the student to become aware of robots. No attempt has been made by any curriculum committee or researcher to identify the instructional content that should comprise a module on robotics for secondary school students. This void in the curriculum guide helped to provide a problem to be solved by the research.

Problem Statement

The problem for the study was to identify and organize the instructional content for a module and its units of instruction, on robotics. A module with units of instruction for the teacher that could be integrated into the elective strand of the Computer Processing 10-20-30 curriculum guide, using robot topics as content organizers.

It was not the purpose of this study to pilot test the module or the units of instruction after each had been developed. The results of this research will be the recommended module and its supporting units of instruction that a teacher might integrate with other modules that are available for Computer Processing 10-20-30.

Supporting Objectives

The following objectives support the major purpose of the study:

To identify the organizational structure that the module should have so that the instructional content of the units of instruction that comprise the module have relevancy, cohesion, and progress from the simple to the complex.

This objective was satisfied from the literature review that was conducted to determine what leading authorities had written on curriculum design and on how a module and its units of instruction should be structured so these units within the module progress from the simple to the complex.

To determine if any department of education located in the United States or Canada with responsibility for secondary education had a curriculum or a portion of a curriculum which placed emphases on robotics.

The information collected to satisfy this objective was the review of course materials that were received from research participants to determine commonality of content, which included learning activities, technical terms and structure. Then to correlate this information with that identified by the researcher from the literature to design both the module and its supporting units of instruction.

To survey catalogs of major suppliers of educational robots as well as professional literature devoted to robotics to determine what "robot types" are available on the educational market.

The information collected to satisfy this objective was used to prepare the learning activity component for the units of instructions of the module.

To determine the availability of commercially prepared educational software, both print and non-print, on the topic of robotics that could provide a support function for the units of instruction for high school teachers responsible for teaching Computer Processing 10-20-30.

This information was used in organizing the units of instruction so that teachers would have this information readily available, to help clarify the learning tasks that they would teach to their students.

Need For The Study

Curriculum designers for Business Education as a secondary school subject in Alberta made an attempt to incorporate the latest technological innovations and developments into the computer processing curriculum. That curriculum had evolved from the content of the previous computer programming course, when it was modified in 1985, to a programming and application course with a minimal amount of curricular content taken from the manufacturing sector of the economy. The curricular content that was developed was heavily weighted toward business. Although suggesting robotics as a learning activity, the content did not identify the topics for units of instruction. This void helped to establish a need for this study.

Closely related to this previous need was the need for the secondary school student to learn about the basic functions of a variety of industrial and personal robots. Alberta high school students who graduate within the next four years and beyond should feel little fear or apprehension about entering a work place which has integrated robots and robotic technology with other forms of manufacturing technology. These students must learn that robots have been designed to work in an environment which is unsafe, unhealthy, or where the work is repetitive as well as boring. Students must realize that robots are, and will continue to be, implemented into occupations where they can prove to be cost effective with human beings in order to increase industrial quantity and quality. If these students are properly educated about robotics they will have no misconceptions or fear of this technology but instead will be able to take advantage and control of a very powerful industrial and personal tool.

If the schools of Alberta are to provide curriculum for Computer Processing that is relevant for students who will be an integral part of the labour force of the 21st century then it becomes imperative that the curriculum include a module on robotics. This need becomes readily apparent when the growth curve for use of robotic technology in manufacturing over the past quarter century shows a steady rise. Robotic research and development is also expanding into non-manufacturing sectors, such as, agriculture, medicine, and many other diverse applications, e.g., from shearing sheep, harvesting oranges to assisting the old or disabled.

It becomes incumbent upon instructional designers and instructional planners, as well as curriculum planners in Alberta, to devote a portion of their time to the design of a learning module which contains relevant units of instruction for robotics that a teacher can offer to the student. These designers and planners can no longer avoid learning activities that can be presented to a learner so that the learner becomes literate about robotic technology. Activities that will help keep the learner abreast of the technological developments that are closely related to robots. This helped to establish an additional need for the study.

Significance of the study

The results of the study should have significance for those responsible at the provincial level who develop and design curriculum for computer processing that is implemented at the secondary school level. These individuals should be able to take the recommended module and the units of instruction from the research and have both pilot tested by teachers in selected schools where computer processing is taught. This procedure should be of assistance to other classroom teachers who wish to develop lessons or units of study on robotics because they will have a foundation on which to build.

The results of this study should also have interprovincial significance. Teachers in other provinces, after reviewing the module and its supporting units of instruction, may want to use some or all of the topics from the units of instruction with their students. This should reduce the time required by these individuals to identify and organize the instructional content for these units. This significance could be heightened should teachers in schools in the United States wish to use either the module or selected topics from the units of instruction and incorporate them into their instructional content.

Results from the study may have some significance for those who teach robotics and the application of robots at the tertiary level of education. These individuals may want to consider the results of the research as a base on which to build additional content for their courses.

Operational Definitions

The following operational definitions were selected for this study and will be used throughout the report. These definitions are study specific and have application for no other study but the current one.

Business Education

In Alberta, Business Education is considered as the interdisciplinary study of the principles, procedures and technologies within the business environment which are taught in grades 10, 11, and 12. Within this program a student has the opportunity to learn more about the role of a future participant within a productive society and to build a framework for a successful career. The knowledge, skills, attitudes and habits expected in business assist students, upon completion of high school, to respond to the opportunities and expectations of the world of work. (Alberta Education, 1987, p. 1)

Business Education Curriculum

The Business Education Curriculum is an unofficial document of the Curriculum Branch of Alberta Education which provides direction to administrators and teachers that will help educate students to learn about business and for some of these students to become effective and efficient workers in the world of work. (Alberta Education, 1987, p. 7) One of the major courses of the Business Education Curriculum is Computer Processing 10-20-30.

Computer Processing 10-20-30 (1985)

Published in 1985, the most recent addition to the Business Education Curriculum for Alberta high schools was Computer Processing 10-20-30. This course is offered for 15 credits at the high school level, grades 10, 11, and 12. Computer processing as a course is designed to provide all students with an opportunity to study the impact of the computer on both the individual and society. Programming and software manipulation provide the student with an opportunity to personally direct the computer to help the student solve a wide range of problems from simple to complex. According to the curriculum guide (course guide), students should develop skills and knowledge that will be applicable to all disciplines. This guide goes on to state, "Students have the opportunity [in this course] to develop basic skills for the personal use of the computer, skills that support their career plans, or skills that provide suitable background for post-secondary study" (Alberta Education, 1985, p. 15).

The content of this course includes 18 modules; one is considered to be the core or mandatory for the teacher to teach. The other 17 modules are considered elective modules which introduce students to specialized applications or aspects within a computerized environment.

Curriculum

There are as many definitions for the term curriculum as there are writers who have authored textbooks for curriculum courses at the university level. Of the definitions reviewed, the one by Derr (1977), was accepted for this study. Derr viewed curriculum as a set of things, "which are taught, designated for learning, and given to pupils to be learned by them". (p. 152) A curriculum is comprised of programs and courses of study. A course of study, in turn, is made of a series of sequential, related modules of instructional content. Modules are comprised of units of instruction which are the day to day content organizers to be used by the teacher to present instructional content to be taught to a learner.

Instructional Objective

Mager (1984), in, Preparing Instructional Objectives, indicates that instruction is only as successful, or effective, to the degree that it accomplishes what it sets out to accomplish through its instructional objectives. To assist educators to specify and communicate instructional intents, Mager recommends the use of well-stated objectives which are in his terms, "a description of a performance you want learners to be able to exhibit before you consider them competent. An objective describes an intended result of instruction, rather than the process of instruction itself" (Mager, 1984, p. 1).

Mager identifies three characteristics or components of an instructional objective which answer three questions that help the objective to communicate an intent. These are, Performance, (what should the learner be able to do?), Conditions, (under what conditions do you want the learner to be able to do it?), and Criterion, (how well must it be done?). (p. 21)

Module

In the professional literature there are a number of definitions given for the term module. One example is that found in the International Encyclopedia of Education 1985, (volume 6) which quotes Creager and Murry (1971), who define a module as:

> a self contained and independent unit of instruction with the primary focus on a few well-defined objectives. The substance of a module consists of materials and instructions needed to accomplish the objectives. The boundaries of a module are definable only in terms of stated objectives. (p. 3398)

There is no single definition for this term that is acceptable to everyone. For the purpose of this study the definition given by Alberta Education (1987) was acceptable to the researcher. This provincial agency relates time to instruction in its definition: "a module is a specific amount of subject matter and related activity, as set forth in the curriculum guide, to be covered within 25 hours of classroom instruction time" (p. 9).

The anatomy of the module for teacher use as outlined by Alberta Education in the Computer Processing 10-20-30 curriculum guide includes:

1. the purpose(s) for the module.
2. status of the module (CORE/ELECTIVE).
3. prerequisites or corequisites.
4. equipment or facility requirements.
5. "TOPICS" which focus on the objectives for the module.
6. "LEARNING TASKS" which further define the "TOPICS".
7. "TEACHING NOTES" which clarify the "LEARNING

> TASKS" or offer suggestions as to how the learning tasks could be addressed. (Alberta Education, 1987, p. 10)

The purpose of a module according to Alberta Education can be found in the general objectives of the module which give it purpose and direction. The general objectives have supporting instructional objectives which give specificity to the units of instruction that make up the module.

Program

Pautler (1971), sees a program as the pursuit of a certain specialization such as cosmetology, or electronics, etc. This author continues by defining a course as one segment of the total program and a unit as a smaller sub-division of a course. (Pautler, 1971, p. 52)

Robotics

The term robotics is so recent that it often does not appear in standard dictionaries. It does, however surface in introductory level books such as, Robot Tech Talk by Radlauer and Mather (1985). These authors define robotics as, "the science, study, manufacture, and use of robots" (p. 50). Simply stated robotics is the study of robots.

Unit of Instruction

Preitz (1969), in research that was directed at designing units of instruction for treatment media courses, that could be used to prepare occupational therapists with requisite psychomotor skills, defined a unit of instruction as, "One of a series of fundamental learning experiences which, when they are organized into a teaching sequence, comprise a course of study and involve educational activities.

Each unit has one or more objectives and coherence" (p. 16).

Population And Sample

Three discrete populations were needed to bring the research to a conclusion.

The first population included all supervisory personnel at the state and the provincial level who give leadership to vocational, technical, and industrial arts education in both the United States and Canada. This population was obtained from the September (1987), issue of School Shop which includes a "Directory of Supervisory Personnel for North America". This directory lists the name and address for each supervisor. The purpose for involving these individuals in the study was to have them identify the secondary school teachers in their jurisdictions who teach units or lessons on robotics.

The second population included those secondary school teachers who were identified by either state or provincial supervisory personnel as teachers of units of instruction or who devoted a portion of their course to robotics. These teachers were considered by either the state or provincial supervisor to be innovators in teaching their students to become aware of this evolving technology.

The third population for the research was taken from the membership of Robotics International, a division of the Society of Manufacturing Engineers. This organization maintains a directory of members who have a major responsibility for teaching a course, or courses in robotics at the tertiary level of education. From the population listed in the Directory of Robotics Education and Training Institutions 1984-85 a stratified random sample of ten individuals was taken to become the Panel of Experts. This list was stratified into two groupings, tertiary educators and industrial trainers. The latter group was eliminated from the study. The randomization procedure recommended by Moses (1986), in Think and Explain with Statistics was followed. To select this sample a number was assigned to each member on the stratified list. A preliminary list of random numbers was computer generated and scanned for duplication. This method follows closely that recommended by Moses who defines a random sample as, "one that is drawn by a method such that every possible sample had an equal chance of being the one drawn" (p. 83). The criteria outlined below were used to identify the individuals who served on the Panel of Experts.

Criteria for Selecting the Panel of Experts

To establish the Panel of Experts the following criteria were established.

The individual had to be listed in the Directory of the Robotic Education and Training Institutions 1984-85, published by Robotics International.

The individual had to be an educator who teaches robotics at the tertiary level.

The institution where the individual taught had to have a robotics laboratory.

One member had to teach at the secondary school level and have written on the topic of Robotics.

The role of the Panel of Experts in the research is described in the section on Methodology.

Limitations

The research was limited to:

those teachers who were identified by provincial and state officials as teaching a course or a portion of a course in robotics.

the course materials that were received from teachers who were invited to submit these material.

the type and variety of course materials that were received for analysis.

the extent of knowledge and background that the Panel of Experts had toward organizing and structuring instructional content from the simple to the complex.

Methodology

The following methodology was used by the researcher to develop the recommended module and its units of instruction for robotics that resulted from the investigation.

The supervisors for either industrial education, industrial arts, or technical education from each state of the United States and from each province of Canada were identified from the, "Directory of Federal and State Officials" listed in the September issue of School Shop (1987). A letter of request asking these individuals to cooperate in the research was prepared by the researcher and reviewed by the Faculty Advisor. Following revision, the letter was mailed to each supervisor. The letter requested that the supervisors cooperate in the research by supplying the researcher with names of secondary school teachers in their jurisdiction who offered either a course or a portion of a course in robotics. A copy of this letter is part of the content of Appendix A, page 130. Of the 65 supervisors who were contacted, 31 responded. This represented a 47.7 % rate of responses.

To increase the rate of return a follow-up letter was sent to those supervisors who did not respond to the initial letter of request. Part of the contents of Appendix A, page 140, is a copy of the follow-up letter. This procedure yielded an additional 10 responses for a total rate of response of 63.2 %. Included in Appendix A, page 131, is a list of the names and addresses of the supervisors who were contacted through the mail.

Of the 41 supervisors whose letters were received, 17 were able to provide the information requested. The number of teacher contacts identified by each supervisor varied from zero to twelve. In other instances only one name was provided. These names were placed on a list and from this list a mix of urban and rural teachers were selected to participate in the study. Both of these areas were identified using Rand McNally Goodes World Atlas, (1984), 16th edition.

A letter was prepared and sent to each teacher on this list. The purpose of this letter was to request that these teachers become involved in the study by providing the researcher with a copy of the course material they used to organize lesson content to teach robotics. A copy of this letter makes up Appendix B, page 147. Also included in Appendix B, page 142, is a list of teachers to whom a letter was mailed. Of the 35 letters that were mailed 11 teachers responded. This represented a 31.4 % rate of response for the teacher cohort. Due to time restrictions no follow-up letter was mailed to those teachers who did not respond by the deadline date given on the initial letter of request. Of these 11 teachers only 5 provided curriculum materials that could be considered relevant for this research. In addition, two state supervisors provided either a curriculum guide or a course guide.

Course materials in the form of course guides, course outlines, and a curriculum guide were received and reviewed by the researcher to identify structure, scope and sequence as well as to determine commonality of content. These materials were also reviewed to identify performance objectives and the method of delivering content to the learner. A charting procedure was designed and used in making this analysis and review. The information that was obtained from the analysis helped to provide the researcher with perceptions and guidance in formulating and organizing the units of instruction that could be structured from simple to complex for the Robotics Module for Computer Processing 10-20-30. These units of instruction that were developed were modelled after the structure recommended by Alberta Education (1985), in Computer Processing 10-20-30.

To identify professional personnel who were responsible for teaching a course in robotics at the tertiary school level, correspondence was initiated with Robotics International, requesting that a copy of the Directory of Robotics Education and Training Institutions 1984-85, be made available to the researcher. The Society for Manufacturing Engineers readily fulfilled the request when it forwarded a copy of the Directory which lists the names and addresses of 300 educators or industrial trainers who teach robotics in their place of employment. This list was stratified into two groups with one group being removed from the investigation. From the list of tertiary educators ten names were randomly selected using the procedure recommended by Moses (1986). Those selected were invited to serve as members of the Panel of Experts. A list of these members can be found in Appendix C, page 149. The criteria that were established for selecting members of the Panel and the randomization procedure used in selecting these individuals is fully described in a previous section of this chapter titled "Criteria for Selecting the Panel of Experts". It was the responsibility of the Panel to review the suggested module and its units of instruction and to recommend changes they thought relevant and significant.

From the results of the review of the Panel the module and its units of instruction were revised and modified. The results of this effort were then considered as the recommended module and its units of instruction for the Computer Processing 10-20-30 course of study. It was not the purpose of the study to pre-test the module in a classroom situation.

Organization of the Thesis

The thesis will be organized according to this structure.

Chapter I.	Introduction and Research Design.
Chapter II.	Review of Related Literature and Research.
Chapter III.	Identifying Instructional Content.
Chapter IV.	Designing the Module on Robotics.
Chapter V.	Summary, Findings, Observations, and Recommendations.

CHAPTER II

Review of Related Literature and Research

Introduction

The content of the previous chapter included the research design. Part of the research design was the major problem that had to be solved which was to design units of instruction for the module on robotics for the teacher to use. The second chapter and its contents are closely related to both the problem statement and to the content of the first chapter. This chapter is divided into four interrelated sections. Thus, the main thrust of this chapter is to review the literature and research related to this study.

The first section of this chapter will be a synthesis of the literature reviewed by the researcher on robots and/or robotics. This review was made to identify terms for the emerging robot technology that is commonly used by the different authors-terms that subsequently could be part of the various units of instruction. Another purpose for this review was to determine if there was congruence among authors about the function and operations of an industrial robot. Other robot types such as personal robot, health robot, and educational robot is also reviewed.

Closely related to this section is the second section which deals with the review of the literature that was conducted on curriculum design and curriculum development. This review was made to determine what renowned authors of university type curriculum textbooks had written on the scope, sequence, and structure of the elements that comprise a curriculum.

The third section concentrates on the literature that deals specifically with modules and the literature on the structure of a module that is advocated by specialists who wrote about the individualization of instruction. The literature involved in this portion of the review had to be published within the last decade and a half because it reflects the most recent thought by specialists in the delivery of instruction through personalized or individualized modes.

The fourth and final section is devoted to a review of research that is related to the current study. The main purpose for including this section was to determine if similar studies had been completed in North American tertiary institutions and if the results of these studies had any implications for the current study.

A Brief History of Robots

Due to prevailing economic and labour conditions, there exists a demand for Canadian industries to compete with those of Japan, West Germany and the United States. Schwarz (1981), illustrates how the United States economic situation can be analogous to the state of North America's current manufacturing situation. This authority identifies reasons why the United States and Canadian economies have faltered, while the Japanese and West German economies have flourished, achieving not only significant gains in productivity, but also, reputations for manufacturing superior quality products.

Schwarz points out that the industries which have been the backbone of the North American economy: automobile and steel, are falling behind in world competition. Even if billions of dollars were invested in new equipment and plants, as projected, the immediate outlook is not too encouraging. With the drop in inflation some cyclical pick-up is expected in productivity, but, not nearly enough to catch-up to recent world status.

The improvement in productivity and product quality in this decade is largely dependent on the new manufacturing technologies. One of the most promising of these is robotic-specialized machines which perform tasks, more accurately, more consistently and at a lower cost than humans. Robots are capable of working around the clock performing repetitive motions tirelessly, freeing workers from tedious jobs, and in some cases freeing workers from environments which are harsh and/or hazardous.

Current robots can only operate in an environment that is carefully structured and oriented. Should the work-piece be of an incorrect dimension, or its orientation in the wrong position, the robot will fail. (Hunt & Hunt, 1983, p. 9) Rehg (1985), acknowledges the fact that robots have a tremendous capability but this authority also acknowledges that the most poorly prepared worker is better equipped than a robot to handle many situations that might occur in the work cell such as when the worker drops a part on the floor or when a hopper/feeder is empty. (p. 7) Rehg gives two reasons that explain the rapid development in robotics between 1970 and 1980 in American industry. The reasons given are economics and hardware. This author continues by pointing out that the shortage of skilled operators and the increase in wages, resulting from inflation of the 70's gave the robot industry in the United States an edge in the market. (p. 5)

Initially used as forms of entertainment and amusement, robots have evolved to complex space pioneers i.e., the Viking I Martian Rover. (Chester, 1983, p. 42) As early as the Middle Ages, two human sized machines dressed in medieval garb struck a clock tower's bell on the hour. These simple mechanical robots called automatons were powered by mechanisms which were housed inside these huge clocks. In the early eighteenth century two professional clock makers created a small female musician which played the piano and an automaton school boy which could write a sentence. (Lambert, 1985, pp. 10-11)

A new form of mechanical control was developed during the eighteenth century in Austria. It consisted of a puppet theatre where tiny figures perform various tasks while an organ played an accompanying tune. All movements were powered by water and were controlled by a system of cams and levers. By the end of the eighteenth century, the control mechanism became much more sophisticated and complex. A popular example was Vauconson's duck. Reported to be first shown in 1738, it would walk, eat, quack, drink and splash in water. (Asimov & Frenkel, 1985, p. 5) Although these simple mechanical devices were elaborate toys they did possess robot like characteristics which caused them to move under their own power. Toy robots continue to intrigue and entertain children of the last half of the twentieth century. While many robot toys can imitate the anatomical movements of a human being, they do not perform useful work.

In 1938 Pollard and Roselund, two Americans, designed a programmable paint spraying mechanism for the Devilbiss Company. (Rehg, 1985, p. 3) It was not until 1954 that the concept of an industrial robot became reality when George C. Devol applied to the United States Patent Office for a patent on, "programmed artical transfer" (no. 2,988,237 granted June, 1961). The granting of this patent signified the advent of the industrial robot. This concept was followed by a digitally controlled robot that was developed four years later by Consolidated Control Inc. In 1962, the first models of Unimate and Versatran (versatile transfer) made their debut into industry and became the prototypes for a number of industrial robots.

Jobs that robots can perform in a work cell can be placed in two major categories: hazardous jobs and repetitive jobs. Many of the hazardous jobs involve welding, painting, and various pick-and-place operations which can be injurious to humans. Hazardous jobs may involve toxic fumes, weight of materials being handled, temperature of the material being handled, danger of working near rotating or press machinery, or environments that contain high levels of radiation. (Hoekstra, 1986, p. 3) Repetitive jobs are jobs that require little or no judgement and little or no skill to perform but are necessary to complete the manufacturing of products.

Definitional Problem

What is a Robot ?

When asked to define a robot the average individual conjures up images of an intelligent, flexible, decisive, mechanical device capable of forecasting the future and fluent in 180 different languages. Most of these misconceptions are the results of the influence of science fiction novels and films such as Star Wars with characters such as R2D2 and C3PO. Industrial historians have traced the first reference of the word robot to the 1921 play R.U.R. "Rossum's Universal Robots" by the Czechoslovakian playwright, Karl Capek. Capek derived the word robot from the Czech word, robota, which means "serf" or "one in subservient labor" (Rehg, 1985, p. 3).

Although mechanical devices have been in existence for centuries, the term Robot is relatively new. Despite all the attention Industrial Robots (IR's) have been receiving, in the past decade and a half many people are still confused as to what they really are, what they look like, and what they can do. Thus, a definitional problem becomes apparent, because there is no consensus among industrial leaders how a robot should be defined. This is true especially between Japanese and American experts. Instead of defining what a robot is, these authorities chose to describe the work functions performed by the robot.

Hunt and Hunt (1983), indicate that a very broad definition for the term robot originated with the Japan Industrial Robot Association (JIRA). These authors failed to include that particular definition in Human Resource Implications of Robotics. The official definition that was presented by the Robot Institute of America (RIA) in 1979 at the 11th International Symposium of Industrial Robots that was adopted by those who attended is narrower in its content and is the accepted international definition; "A robot is a reprogrammable multifunctional manipulator designed to move material, parts, tools, or other specialized devices through variable programmed motions for the performance of a variety of tasks" (Asimov & Frenkel, 1985, p. 21). As a reprogrammable, multifunctional manipulator a robot is able to perform the same task on identical workpieces repetitively; it can perform different tasks on the same workpiece; or it can be reprogrammed to perform entirely new tasks. (Hunt & Hunt, 1983, p. 8) Reprogrammable means that the machine has the capability of being reprogrammed to perform new or different tasks or that it has the capability to change the motion of its arm or tooling. (Rehg, 1985, p. 7) To be classified as a multifunctional manipulator a robot must be able to perform a number of different functions which are interrelated with the program and tooling used.

Hoekstra (1986), in analyzing the components of the definition of a robot, states that "A manipulator is an arm (or hand) that can pick up or move things" (p. 3). Hoekstra goes on to say that through the correct commands the manipulator arm can be taught to do different jobs. The variety of jobs that a robot can perform is limited only by the creativity of the application engineer.

The definitional problem is compounded with the use of the adjectival form of the noun robot which is used to describe the study and development of robots as robotics. (Billard, 1982, p. 16) The first known use of the word robotics was in reference to the rules or laws of robotics which were identified by Isaac Asimov in 1950, in his book entitled I, Robot. Asimov described, three laws of robotics to determine the character of a robot. These three laws were: (1) a robot must do no damage to man, (2) a robot must be subordinate to man, (3) a robot must protect itself from damage. (Asimov & Frenkel, 1985, p. 13) Asimov presumed that a robot must be subordinate to and useful for man, this concept is still valid thirty-eight years later. Asimov and Frenkel, (1985), define robotics as, "the now-accepted term for the science and technology of the construction, maintenance, and use of robots" (p. 13).

Robots Classified

Industrial Robots

Importantly, a robot differs considerably from a parts transfer mechanism or a dedicated machine in that the robot's motion pattern can be changed through reprogramming. Reprogramming was accomplished in the early days by adjusting the physical mechanisms of non-servo robots, or more recently in the case of servo robots by altering the software in the (controlling) computer. Non-servo robots are limited sequence robots, such as pick-and-place robots, which are capable of limited linear motions. These robots are relatively simple in terms of their control systems and computing/software requirements but have a high degree of "repeatability" which is the ability to consistently return to exactly the same spot once properly programmed. The more sophisticated, servo robots can be programmed to direct a task because they have computers with memory and computer-controlled motors (servomechanisms). Servomechanisms may include servo-valves or special circuits or specialized software-base controls which enable the computer to maintain a two-way feedback communication system between computer and controlling motors. This communications system monitors and controls all movements of the robot, its direction and speed, and has the ability to interact with auxiliary devices through the use of sensors.

A servo system can be explained as a high-powered drive motor being controlled by a low-powered control mechanism. Rehg (1985), states that an, "electronic interface amplifies the small control signals in order to operate the high-power drive and move it in the desired direction" (p. 93). Servomechanisms use electronic sensors to constantly monitor the position of the drive thereby creating a closed loop effect. In non-servo or open-loop machines the controller does not use feedback sensors to control the movements or locations of parts. (Rehg, 1985, p. 93)

Of those who have written textbooks on robotics, Hoekstra (1986), and Rehg (1985), in particular both agree that there is a consensus among robot manufacturers and users how to classify robots. One classification system uses the robot arm geometry based on the work area produced by the robot arm. (Rehg 1985, p. 25) These work areas are called work envelopes which describe the geometric shape in which the industrial robot functions and include rectilinear, cylindrical, or spherical. These are related to the types of joints (prismatic or rotary), and the number of joints of each type. In a rectilinear work envelope the robot will move its end gripper through any position in a cube or rectangle. (Rehg p. 25) For the cylindrical work envelope the robot can move its gripper within a volume that is described as a cylinder. (Rehg p. 25) When a robot moves its gripper within a volume that is described by a half sphere it is classified as a spherical robot. (Rehg p. 25)

Closely related to classifying robots by the geometry of the arm is to classify a robot by the movements that the manipulator can make within the work envelope. These are: pick-and-place, point-to-point, and continuous path. Normally a pick-and-place robot is limited to two end points. These robots pick up a material, parts, or sub-assembly and move it from one location to another. These are the simplest of robots and are non-servo. A point-to-point robot can be programmed to move from any point to another point in the work envelope. According to Hoekstra (1986), these robots can move more than one of its axes at a time. (p. 29) In moving from point to point the robot does not necessarily move in a straight line. In fact the trajectory is usually unknown and unpredictable. Continuous path robots can be programmed to follow any path such as an arc, a circle, or a straight line. (Hoekstra 1986, p. 32) This robot can be programmed to store thousands of individual points in its memory. A point-to-point robot is limited to several hundred points. (Hoekstra, p. 32)

Robot Components

The major components that comprise the basic system of an industrial robot are the manipulator, the power supply and the controller. (Hoekstra, 1986) The manipulator is an arm which is a mechanical device driven by either of three power sources: electric servo-motors, pneumatic devices or hydraulic actuators. (Rehg, 1985) These drive elements are an integral part of the mechanical arm to give the manipulator its various movements. These movements are referred to as degrees of freedom. (Hoekstra, 1986) According to Rehg (1985), a degree of freedom is, "Every joint or movable axis on the arm is considered a degree of freedom. A machine with six movable joints . . . is a robot with six degrees of freedom" (p. 17). A single-axis robot can only rotate the manipulator. If the manipulator moves up and down as well as rotating the robot is a two-axis robot. A three-axis robot is one where the manipulator not only rotates and moves up and down but has the capability to extend its arm or reach. In addition to these major axis movements most industrial robots have some minor axis movements found in the wrist of the robot. These minor movements or axes are pitch, which bends the wrist up and down; roll, which is the twisting movement of the wrist; and yaw, the side to side movement of the wrist. (Hoekstra, 1986, p. 7) The combination of the movements of the major axes and minor axes gives the robot six possible degrees of freedom. (Hoekstra, 1986, p. 7)

End Effectors

Without some type of tooling interfaced with the robot arm the robot has no production capability. Tooling to perform the work task is attached to the tool plate at the end of the manipulator or arm. This tooling is identified as end-of-arm tooling or end effector which has to grasp, lift and manipulate workpieces without causing damage or releasing them. These hands of the robot are usually designed specially for a particular application. Engelberger (1980), lists eight methods of grasping a material while it is being processed. Among these are: "mechanical grippers; hooking on to a part; lifting and transferring a part on a thin platform or spatula; scooping or ladling; electromagnets; vacuum cups; sticky fingers, using adhesives; quick disconnect bayonet sockets" (p. 41).

The function of the end effector tooling or gripper is to hold the part as the robot presents it to the tool for the work to be done or vice versa, which is, to hold the tool as the robot moves it to work on the part. (Rehg, 1985, p. 63) According to this authority the end-of-arm tooling should possess these characteristics:

> 1. The tooling must be capable of gripping, lifting, and releasing the part or family of parts required by the manufacturing process.
>
> 2. The tooling must sense the presence of a part in the gripper, using sensors located either on the tooling or at a fixed position in the work cell.
>
> 3. Tooling weight must be kept to a minimum since it is added to part weight to determine maximum payload.
>
> 4. Containment of the part in the gripper must be assured under conditions of maximum velocity at the tool plate and loss of gripper power.
>
> 5. The simplest gripper which meets the first four criteria should be the one implemented. (p. 63)

Standard grippers on a robot can have two closing motions angular or parallel. The program commands the robot controller to open or close the gripper as it moves through the production cycle. The power used to open or close a gripper can be pneumatic, hydraulic, electric or spring power. In most applications to open or close the jaws of the gripper, pneumatic power is used. (Rehg, 1985, p. 66) Where a high clamping force is required to move large, heavy loads hydraulic power is used. Rehg states that, "grippers are also designed to hold power tools in the same way that human hands do" (p. 77). When the jobs are dirty, dangerous, and dull for humans to perform. Grippers have been designed to hold drills, welding guns, glue and sealer dispensers, spray guns, grinders and sand blasters. These tools when fastened to an end-effector are likely to be given the same characteristics they would have had they been manually manipulated. To pick up the part, material, or sub-assembly to be worked on, two of the main factors to be considered are: how the grippers should grasp and how hard should that grasp be.

Power Supply

Engelberger (1984), states that, "a power system or drive system is required for each of the robots articulations. In addition to driving the arm, the hand and the wrist, most types of grippers also need a drive mechanism for the functions of holding and releasing" (p. 33). Although a robot may use a combination of drive systems Heath (1985), identifies that, "robots are powered primarily by hydraulics, pneumatics, and electrical means" (p. 170). Rehg (1985), explains that hydraulic power systems can consist of such parts as a fluid tank, pump, surge tank, control valves, lines and actuators which provide manipulator movement by pumping oil or some other fluid through the system. The high-pressure hydraulic oil is forced into one end of a cylinder and in turn pushes or rotates actuators to produce the desired motion. (p. 39) Hoekstra (1986), identifies the required plumbing and concerns of fluid storage as disadvantages of the hydraulic robot. Rehg (1985), indicates the one primary advantage of a hydraulic system is a very high power-to-size ratio which allows for manipulation of large loads.However, Hoekstra (1986), points out that hydraulic robots lose repeatability when the load on the manipulator increases. (p. 155) They also require substantial warm-up time. These experts agree that there are many more disadvantages than advantages for the hydraulic system but there are a significant number in industrial applications which require large payloads. (Rehg, 1985, p. 41)

Pneumatic systems are used primarily for the simpler pick-and-place robots that are non-servo controlled although pneumatic devices are used on some servo controlled robots for the end-of-arm tooling. According to Rehg (1985), the basic system components in pneumatics are the same as those of a hydraulic system. (p. 41) Pneumatic powered devices use compressed air to provide the movement of the robot arm. Air is directed through pipes or hoses to cylinders where the pressure extends a piston or rod. Rehg (1985), gives these advantages for a pneumatic power source, "It is available in most manufacturing areas; pneumatics is an inexpensive, well-developed technology; and system leaks do not contaminate the work area" (p. 41). Research and development in feedback controls is improving the ability of the pneumatic system to provide proportional operation and multiple stops which Rehg (1985), states is the primary disadvantage. (p. 41)

The electric system includes a source of electrical power and an electric motor. Hoekstra (1986), indicates that the advantages of the electrically powered robots are the simplicity and maintenance of the drive. Electric-drive robots are becoming more repeatable by taking advantage of complex electronic circuitry to monitor the robot's position and to correct for the variation due to load. (p. 156) Rehg (1985), identifies three advantages of an all-electric drive robot, "no generation of hydraulic or pneumatic power is required, no contamination of the work space occurs, and low noise level is maintained while operating" (p. 42). Rehg (1985), points out the disadvantage to be, "the limited lifting or payload capability . . . as compared to the hydraulic counterpart" (p. 42).

Control Systems

Engelberger (1980), explains that a control system can vary in complexity from its simplest form as a series of adjustable mechanical stops or limit switches to the other extreme of a computer and a computer program. (p. 17) Rehg (1985), indicates that current industrial robots can be divided into the two types, "servo" or "non-servo", depending on the type of control system used. The non-servo or open-loop machines do not use feedback sensors to control drive power to the arm whereas the servo-driven robots use various feedback sensors. With the use of feedback sensors the position of the robot can be calculated and adjusted. (p. 93)

Hoekstra (1986), identifies the following five basic types of robot controls most commonly used, "the drum controller, the air logic controller, the programmable controller, the microprocessor control, and the minicomputer" (p. 33). The oldest type of controller is the drum controller, which can only be used with a pick-and-place robot. The drum controller is similar to the drum in a music box. As the drum rotates small pegs roll across switches which are wired to pneumatic or hydraulic valves and in turn control the movement of the robot arm. The air logic or pneumatic logic controller is used to control pneumatic pick-and-place robots. The control is determined by a system of connected tubes to valves and timers which open and close the robot's main valves. The programmable controller (PC) is used for many control functions in the automated factory as well as to direct the motions of the robot arm. The PC uses electronic circuitry and components which can be programmed to manipulate the arm. The microprocessor control can be used with pick-and-place robots, point-to-point robots, controlled path robots, and continuous path robots. The microprocessor control is a specialized computer which contains specific memory to move the manipulator. The minicomputer or microcomputer is used to create programs which can be down loaded to a specialized electronic control to move the robot's manipulator. (Hoekstra, 1986, pp. 33-36)

Rehg (1985), expands on the categories of control for the non-servo and servo robots by identifying internal mechanisms and external devices to control the movements of both types of robot arms. Non-servo or open-loop systems have four internal controls which are; fixed hard stops, adjustable hard stops, limit switches, and stepper motors. External controls for non-servo robots are: drum programmers, pneumatic logic or air logic programmers, and programmable controllers. Servo or closed-loop systems use sensors to provide data to the controller so calculations can locate and change the positions of each joint. Of the internal controls, which include those feedback devices necessary to measure and adjust the angle or velocity of the arm, the following are most commonly used: the potentiometer, the resolver, and the optical encoder. A potentiometer is described by Rehg as a variable resistor, the resolver as magnetic couplings used to measure rotation, and the encoders use an interrupted beam of light to determine position. (pp. 96-101)

Robot Types

The following classifications are distinguished by the difference in input information and instruction methods.

The manual manipulator is a robot operated manually by man, an example of this is the "magic hand" used for research in nuclear development, or undersea vehicles.

The sequence robot performs work repeatedly in accordance with a predetermined sequence and conditions. The sequence robot for which alterations to input information are not done easily is referred to as a fixed sequence robot, while for that which alterations are done easily is called a variable sequence robot.

The playback robot is capable of memorizing work procedures, and performs work by reading either a memorized information regeneration system, or a memory regeneration system.

The numerical control robot adopts a control system similar to that used in numerical controlled machines, and controls the manipulator by means of punched paper tapes or cards, or digital switches.

The intelligent robot possesses sensory functions and is capable of making judgements about any changes in the work environment and conditions, and proceeds with the work accordingly. In a sense, it is self programming.

The following descriptions and diagrams illustrate an example of each of the above robots that were documented by Sa[illegible]981. (pp. 15-17). In Figure 1 a sequence robot is used in a pressing operation. The arm in front feeds the parts placed on the right to the press in the center, and then delivers the pressed parts to the parts depository on the left.

Figure 1 A Sequence Robot

This figure has been removed because of the unavailability of copyright permission.

a T

A playback robot for spot welding in an automobile assembly line is shown in Figure 2. There are some 2,000 to 3,000 positions to be spot welded on an automobile. This work is performed by welding robots positioned on both sides of the automobile.

Figure 2 A Playback Robot

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Taken From: Sadamoto, K. (1981). Robots in the Japanese Economy.

Demonstrated in Figure 3 a playback robot is spray painting. The spray gun installed as the end effector performs painting automatically for the star-shaped workpieces suspended on the left.

Figure 3 A Playback Robot used for Spray Painting

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Taken From: Sadamoto, K. (1981). Robots in the Japanese Economy.

Figure 4 shows an intelligent robot used in the assembly of electric vacuum cleaners. The components on the right-hand side of the table are sensed by a digital camera, and the components are assembled on the left-hand side of the table using the two arms in the center. There is also a camera on the left, which is designed to monitor the assembly work performed by the robot.

Figure 4 An Intelligent Robot

This figure has been removed because of the unavailability of copyright permission.

Taken From: Sadamoto, K. (1981). Robots in the Japanese Economy.

Robot Applications

Roughly speaking about 70% of Industrial Robots are used by the automotive, electrical machinery, plastics and metal industries. The number of robot applications is limited only by the design teams' imagination. Generally, robots are doing jobs that are repetitive, hot, dirty, unsafe or hostile for humans to perform. General Motors (GM) now has about 6,000 robots either in use or on order. (Brody, 1987, p. 20) Although the larger robot manufacturing companies, i.e., GMF Robotics are slowing down production, there is a growth in the production of light assembly robots which make use of advanced sensor technologies, i.e., Adept

Technology. (Brody, 1987, p. 22)

Since 1978 a robot has been used to make sheet metal parts and drill tail sections on the F-16 fighter jets. The United States Navy is developing a mobile under water robot to search out mineral deposits on the ocean floor. Nuclear power companies are developing robots to use in case of accidents. Coal mining will soon be completely automated with the use of industrial robots. The Jet Propulsion Laboratory at Pasadena, California has been developing the Mars Rover, a self-propelled vehicle with sensors and decision-making systems. Industrial robots have been used mainly for the following production processes: Pressing. Press work in the metal working industry is usually done in a few seconds; but, is potentially dangerous to the worker. To reduce this danger industrial robots are being used to place and remove pressed parts from high speed metal presses. (There may soon be federal regulations in the United States requiring robots to do these dangerous jobs.) Welding. A robot equipped with a welding gun mounted on the end-effector can perform welding work at a high speed and with high precision. Both spot and arc welding procedures can be accomplished by robots that are in accordance with most welding conditions. Painting. IR's equipped with spray guns in a painting operation have improved coverage and reduced waste. Robots when used in painting are capable of moving at high speed, applying a coat of finish evenly, and robots are unaffected by toxic fumes of the thinner or the paint, therefore less ventilation is required and less dollars expended. Assembly. A new generation of IR's have the ability to recognize shapes and the positions of components on the assembly line. This enables manufacturing to be carried out more quickly and accurately, without additional setup cost associated with specially designed part feeders and fixtures.

Educational Robots

An educational robot is one that was specifically designed for educational purposes to illustrate the basic functions that an industrial robot can perform so that the learner acquires a better understanding of what a robot can do. The cost of the robot depends upon its sophistication, the functions it can perform, its memory capacity, its programmability, and its peripherals.

The number of companies producing educational robots has shown steady growth over the past five years, however, due to a limited market a number of these companies have ceased production of this type of robot, i.e., Mitsubishi RM 101. Currently educational robot designs range from those that closely mimic industrial robot arms to those used entirely for entertainment. Educational robot systems can range in price from $159.90 up to $20,556.00.

Advantages of using educational robots begin with the low cost of the hardware when compared to an industrial robot. The savings in cost could be spent on robot hardware and peripheral equipment allowing for a lower student/machine ratio and increased robotic experiences. Schreiber (1984), offers these following advantages of less-expensive educational robots: their portability, less intimidating, educational features, mobility, educational support materials, and they are highly motivating to the learner. (p. 21) These robots are easy to install and their installation costs as well as maintenance costs are minimal. Another advantage for educational robots is that they are relatively safe for the student to operate.

Curriculum

The Latin root for the word "curriculum" means "racecourse", however this notion has been widely criticized and frequently modified and replaced in modern curriculum literature. (Connelly & Lantz, p. 1163 in Husen & Postlethwaite, 1985) The definition of curriculum has been evolving ever since it was first used in the United States around 1820 at which time it was defined as, "a course of study or training; a product" (Wiles & Bordi 1979, p. 5) Curriculum at that time was equated with the content of textbooks, course outlines, teacher guides, or other finished artifacts of study. There was no indication that any formal research was being conducted to identify the curriculum.

With the expansion of knowledge and the increase in population in public schools, the task of identifying which knowledge was essential knowledge became increasingly difficult. The definition of curriculum began to stretch to fit the growing distance between the planned curriculum and the experiences that were actually encountered. The concept of a product definition, changed in 1935 when Caswell and Campbell acknowledged the socializing function of the schooling process and indicated that, "curriculum should be composed of all the experiences children have under the guidance of a teacher" (Wiles & Bordi, p. 6).

By the mid-1950s, it became increasingly evident that schools had a tremendous influence on students' lives. Not all of these experiences were a result of structured curriculum, some occurred through the congregation of the students themselves. This caused a change in the curriculum definition from one which focused on those aspects that were planned to one which also included the content of general student experiences. This was emphasized in 1957 when Ralph Tyler, a leading authority in education, and more specifically in curriculum, stated, "The curriculum is all of the learning of students which is planned by and directed by the school to attain its educational goals" (p. 79).

Into the 1960's and early 1970's there was an increase in awareness of educational programs and a demand for accountability. The definition of curriculum adjusted to reflect this change in attitude by emphasizing the results and the ends. This was evident in the definition outlined by Wiles and Bordi in Curriculum Development a Guide to Practice (1979), "Curriculum is the planned and guided learning experiences and intended outcomes, formulated through systematic reconstruction of knowledge and experience, under the auspices of the school, for the learners' continuous and willful growth in personal and social competence" (p 45).

> Within the last decade the term curriculum has been used very broadly in the literature to refer to instructionally related educational experiences of students. Curriculum now encompasses educational philosophy, values, objectives, organizational structures, materials, teaching strategies, student experiences, assessment, and learning outcomes. (Fullan, p. 1145 in Husen & Postlethwaite, 1985)

Curriculum authors of today accept the position that the definition of curriculum varies depending on how a particular author conducts his or her own work. Connelly and Lantz in The International Encyclopedia of Education (1985), conclude, "There is, therefore, no way of specifically defining curriculum outside of the context of a particular study, paper, presentation, or policy document under discussion" (p. 1160). Based on what the above authorities wrote the definition as presented under Operational Definitions of chapter one will be used for this study.

Equally relevant to this study are the components of a curriculum. The identification of the components of a curriculum have closely paralleled the evolution of the definition of the term curriculum. The accepted contents of a curriculum have grown to include a common list of topics which have been recognized by today's standards as meaningful. According to Husen and Postlethwaite (1985) : "Curricula consist of five widely agreed upon dimensions or components; (a) a framework of assumptions about the learner and society; (b) aims and objectives; (c) content or subject matter with its selection, scope, and sequence; (d) modes of transaction, for example, methodology and learning environments; and (e) evaluation" (p. 1147).

The goal of this study was to establish the framework of content within a specific subject area and within a module and its supporting units of instruction as opposed to the relationship to the entire program. The task at hand is that of establishing scope and sequence, developing cumulative learning or continuity, and maintaining integration for these course materials.

Oliva (1982), states that there are three concepts of curriculum content that are closely related. These concepts are scope, sequence, and continuity. Scope is defined by this author as, "the breadth of the curriculum" (p. 455). Wiles and Bondi (1979), provide a definition for the term scope that is slightly different than the definition given by Oliva. These authors consider scope to be "The extent of content or objectives (or both) covered by a course or curriculum" (p. 300). Hunkins (1980) categorizes the term scope under "Design Problems" and refers to scope as, "the breadth and depth of content" (p. 230). A more practical definition of scope was put forward by Pautler (1971), "Scope refers to depth and variety within the individual unit. The content of the individual unit determines the scope of the unit" (p. 63). Wiles and Bondi (1979), with their definition place more definitive limits to the concept of scope than do the other authors.

In order for the curriculum to be an effective learning vehicle the content and learning experiences need to be structured to properly serve the learning objectives. Most curriculum authors agree that the most potent factor in determining effective learning is the curriculum organization. On this issue Taba (1962), wrote: "Often the curriculum is ineffective not because its content is inadequate but because it is put together in a way that makes learning difficult" (p. 290).

Oliva (1982), refers to scope as "the what" of curriculum organization, and to sequence as "the when." This author defines sequence as, "the order in which the organizing elements or centers are arranged by the curriculum planners" (p. 468). Hunkins (1980), refers to sequence as, "addressing the problem of ordering the curricular offerings so as to optimize students learning" (p 2[illegible]1).

In much of what has been written on curriculum, Taba (1962), places the greatest emphasis on establishing sequence which to this authority means: "the placing of content and materials into some sort of order of succession" (p. 292). The particular order of that succession largely depends on the presumed logic of the subject. This categorizing of content is addressed in the literature as that which proceeds from the simple to the complex. An example of sequencing is where the exposition is chronological as in a history class, where facts and ideas are arranged in a time sequence so that presentation of later events is preceded by discussion of earlier ones. According to McNeil (1981), principles for sequencing learning from simple to complex goes back hundreds of years. This author defines simple to complex as, "introducing learning activities involving a few factors before activities involving many factors" (p 183). McNeil identifies other principles of sequence such as, "familiar to unfamiliar" and "concrete to abstract" (p. 183).

Taba (1962), believes that for cumulative progression of learning to take place, curriculum experiences must be planned so that there is an increasing complexity of material to deal with. Accompanying this increase there is an assumption that an increase of the maturity of mental reactions will occur. Taba also points out that, "planning a cumulative progression in learning involves planning learning experiences to create a movement from one level of difficulty or complexity to a higher one, from a more limited use of ideas to a greater breadth and from simpler concepts to increasingly more complex ones" (p. 297). Wiles and Bondi (1979), simply identify the definition of sequence as an outcome of the curriculum, "The order in which content or objectives are arranged in the curriculum" (p. 300).

The majority of modern curriculum authors use the many books written by Ralph W. Tyler on curriculum as basal references. According to Tyler (1949), it is necessary to identify learning experiences to structure a curriculum so it is organized into lessons, units, courses, and programs in order to develop a coherent program. (p. 99) Tyler considers the lesson to be the lowest level in this hierarchy. The lesson is written with instructional objectives that are couched in performance terms. A lesson is a discrete unit which is organized under topics the teacher is to teach. Topics are organized into units to complete the structure. Each of these is time referenced with the lesson taking the least amount of time to complete. Program connotes continuities which extend over a long period of time (two to three years) e.g., German I, II, III; while a course may be of shorter duration and is defined by Pautler (1978), "as a segment of the total program"(p. 55). This author continues by defining a unit as, "a still smaller sub-division of a course" (p. 55).

Posner and Rudnisky (1980), take a slightly different approach to organizing a course, "instructional planning consists of organizing instructional content into coherent, feasible design for teaching" (p. 108). These authors begin by identifying the, "Intended Learning Outcomes (ILOs)" (p. 21), as the primary focus in course planning. From the ILO base, or instructional objectives, the course's units are formed by clustering the ILO's into coherent groups, with each group then becoming a unit. (Posner & Rudnisky, 1980, p. 87) From the identified ILOs a "course rationale" (p. 45) can be developed and then the units can be sequenced into a course design that is coherent, not only within each unit, but also across units. (p 108) McNeil (1981), indicates that there exists an organizational design which is structured into: subjects, courses, units, topics, and lessons. (p. 194) However, this author states that his design does not indicate the principle by which the learning opportunities are to be ordered.

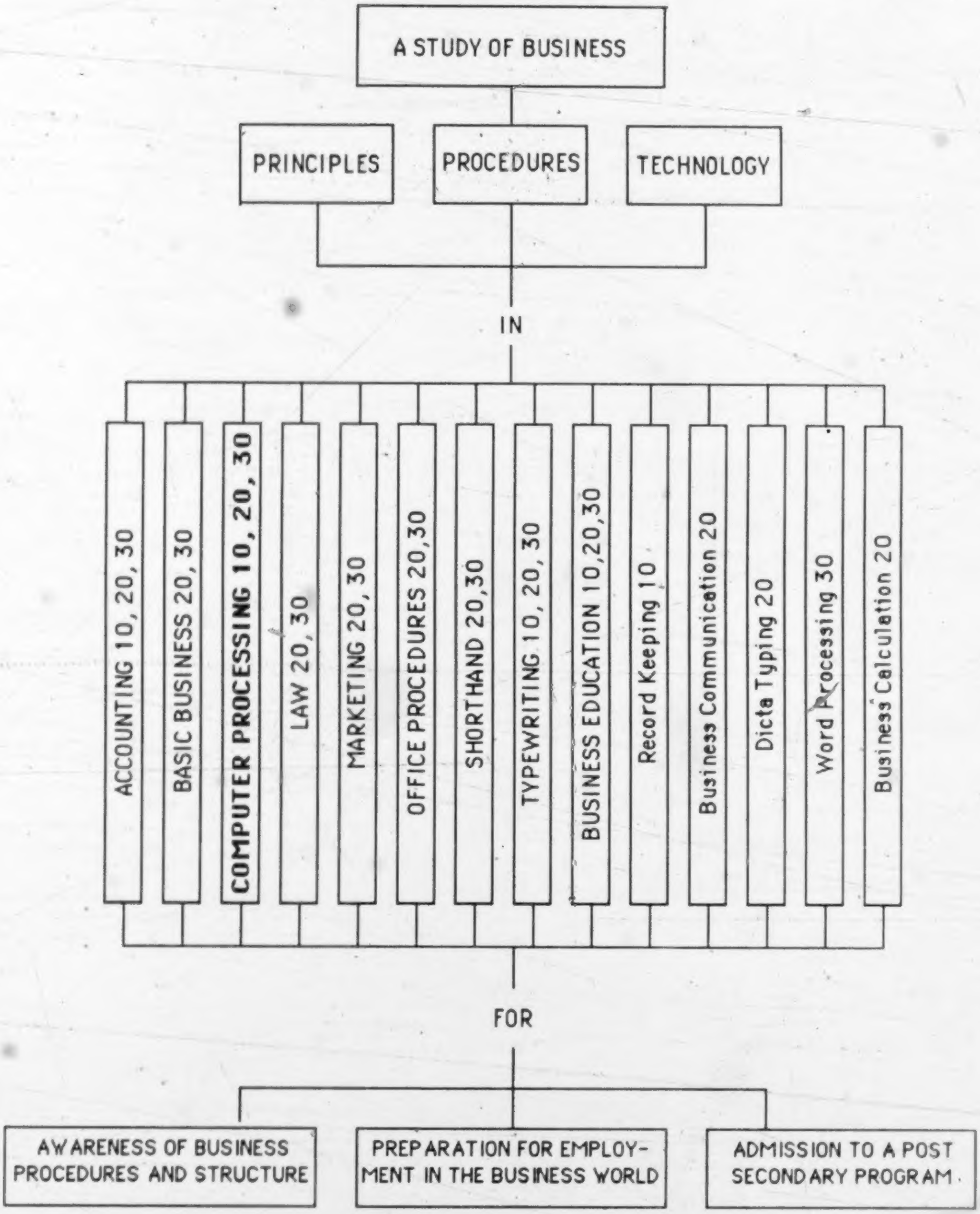
Hunkins (1980), states that the end product of systematic curriculum development is a curriculum resource unit. This author points out that, "a teaching unit must be drawn from the curriculum resource unit" (p. 341). Hunkins continues to explain that a teaching unit contains the same components as a resource unit: "rationale, goals, objectives, topics, activities, materials" (p. 341). Hunkins further identifies the teaching unit's components as materials for a specific class within the light of certain goals. (p. 341)

Oliva (1982), expands on one of Tyler's model schematic to demonstrate the scope and sequence of curriculum components. (p. 160) Oliva identifies curricular rationale as a structure which flows from the, "Source" which includes: students, society, and subject, through to the, "Evaluation of learning experiences" (p. 160).

Alberta Education (1985), also uses a schematic to represent the sequencing of courses within the Business Education program (p. 8) which is reproduced as Figure 5. However the depth of this schematic is limited to the identification of the individual course strands. The strand for the Computer Processing 10-20-30 course is expanded in Figure 6 to show the relationship between the core module and its 18 related elective modules (including the proposed Robotics Module).

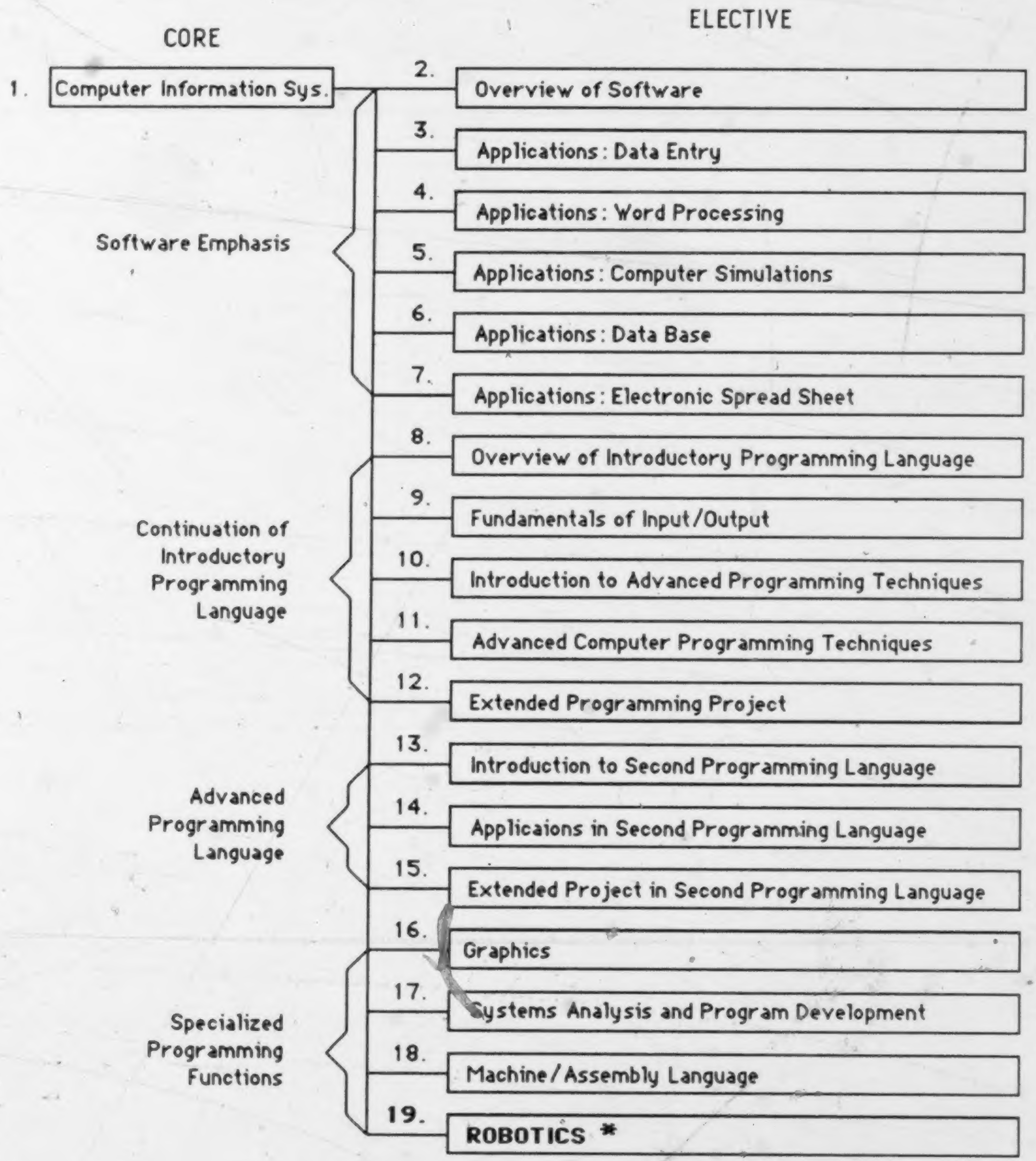
Figure 7 illustrates how the module for robotics is related to the units of instruction a teacher may use to sequence and organize instructional content.

Figure 5 SCHEMATIC OVERVIEW OF BUSINESS EDUCATION PROGRAM


A STUDY OF BUSINESS
PRINCIPLES
PROCEDURES
TECHNOLOGY
IN
ACCOUNTING 10, 20, 30
BASIC BUSINESS 20, 30
COMPUTER PROCESSING 10, 20, 30
LAW 20, 30
MARKETING 20, 30
OFFICE PROCEDURES 20,30
SHORTHAND 20,30
TYPEWRITING 10, 20, 30
BUSINESS EDUCATION 10,20,30
Record Keeping 10
Business Communication 20
Dicta Typing 20
Word Processing 30
Business Calculation 20
FOR
AWARENESS OF BUSINESS PROCEDURES AND STRUCTURE
PREPARATION FOR EMPLOYMENT IN THE BUSINESS WORLD
ADMISSION TO A POST SECONDARY PROGRAM

Taken From: Alberta Education, (1987). Business Education Manual for Administrators, Counsellors and Teachers.

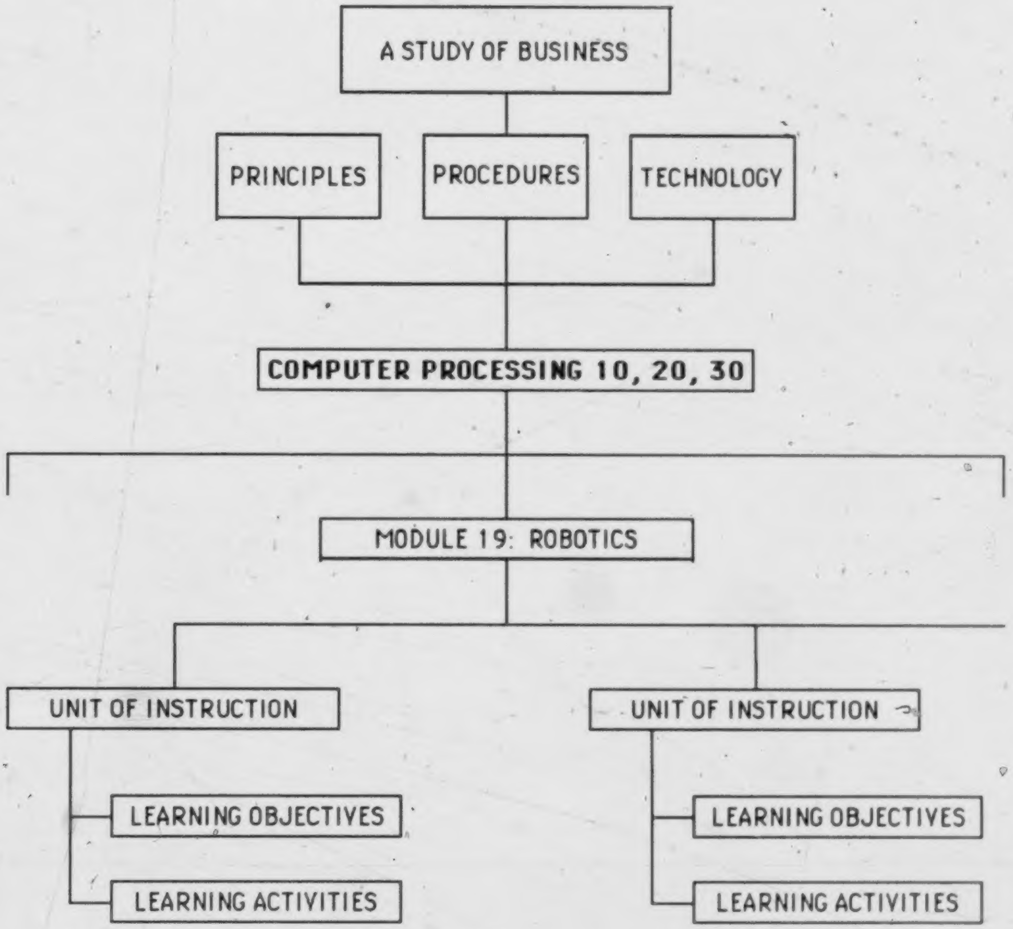
Figure 6 FLOWCHART OF COMPUTER PROCESSING MODULES


CORE
ELECTIVE
1. Computer Information Sys.
2. Overview of Software
3. Applications: Data Entry
4. Applications: Word Processing
Software Emphasis
5. Applications: Computer Simulations
6. Applications: Data Base
7. Applications: Electronic Spread Sheet
8. Overview of Introductory Programming Language
9. Fundamentals of Input/Output
Continuation of Introductory Programming Language
10. Introduction to Advanced Programming Techniques
11. Advanced Computer Programming Techniques
12. Extended Programming Project
13. Introduction to Second Programming Language
Advanced Programming Language
14. Applicaions in Second Programming Language
15. Extended Project in Second Programming Language
16. Graphics
17. Systems Analysis and Program Development
Specialized Programming Functions
18. Machine/Assembly Language
19. ROBOTICS *

* Recommended

Taken From: Alberta Education, (1987). Teacher Resource Manual Computer Processing 10-20-30.

Figure 7 SCHEMATIC OF MODULE 19: ROBOTICS


A STUDY OF BUSINESS
PRINCIPLES
PROCEDURES
TECHNOLOGY
COMPUTER PROCESSING 10, 20, 30
MODULE 19: ROBOTICS
UNIT OF INSTRUCTION
LEARNING OBJECTIVES
LEARNING ACTIVITIES
UNIT OF INSTRUCTION
LEARNING OBJECTIVES
LEARNING ACTIVITIES

Module

Depending on the context in which it is used, the word module, can have different meanings within different environments and among different authors. Amid the field of education authors who have written textbooks on the individualization or personalization of instruction, the term module has evolved to refer to a vehicle of learning which emphasizes the concept of individualized instruction. Weisgerber (1971), in Perspectives in Individualized Learning, provides this definition: "A module is a format incorporating an instructional unit. Students may spend varying lengths of time working individually toward the achievement of the instructional objectives in the module" (p. 260).

Weisgerber (1971), contends that five criteria should be used in the design of a self-instructional module. These criteria should follow a logical sequence which should include a comprehensive list of broad objectives, behavioral specific objectives, prerequisite objectives or tasks, learning activities and performance (evaluation) criteria. (p. 261)

Pascal and Geis (1977), coauthors of Designing Instructional Modules, support the definition for a module given by Weisgerberger. These authors state that a module is, "a self-contained independent unit of a planned series of learning activities designed to help the student accomplish certain well-defined learning objectives" (p. 15). Pascal and Geis also indicate there are a number of basic characteristics that a module must possess if it is to be effective. These are flexibility, motivation, cooperation, objectives, feedback, recycling, mastery and validity. (p. 16)

Musgrave (1975), in Individualized Instruction, uses the term, "Programmed Instruction Module" when referring to a self-contained unit of instruction which he describes as, "written in behavioral terminology, that is a part of a total instructional program" (p. 98). Musgrave states that there are seven parts which are contained in programmed modules if these modules are to be effective with the learner: "rationale, prerequisites, objectives, preassessment, enabling activities, post assessment, and remediation" (p. 99).

In the Dictionary of Instructional Technology, Ellington and Harris (1986), define a module as "an organized collection of learning experiences that have been assembled to achieve a special group of related objectives couched in behavioral terms" (p. 10). These objectives according to Mager (1984), should consist of three interrelated components: tasks, conditions and criteria and should reflect the terminating behavior of the learner after instruction.

It should be evident from what is written above that there is consensus among authors who have written on modules and their use to present instructional content to a learner to individualize or personalize instruction. There is agreement among these authors that a module, if it is to be effective, should contain a rationale statement, well defined learning objectives that are explicitly written so their meaning and intent is clear to the learner as well as to others, and learning activities for the learner to perform if the objectives are to be achieved. The rationale statement provides an explanation to the learner or to the teacher "why" the content of the module should be acquired or taught. This statement is given support and direction by the performance objectives which describe "what" the student is expected to be able to do following instruction. To achieve these objectives integrated into the module are learning activities that the learner must successfully complete in order to achieve what is prescribed in the objective.

After close scrutiny of what these authors have written it becomes evident that the modules they describe are student centered and not teacher centered. Regardless of the end user of the module it should include the components advocated by Musgrave, which were previously discussed. Curriculum guides published by the Curriculum Branch of Alberta Education include modules that are teacher centered so the teacher can use these modules to organize lesson plans to teach content from these plans.

Alberta Education (1987), has adopted the term module to refer to the content which when assembled from simple to complex comprise a course of study. A module has been characterized by this provincial government agency as a specific amount of subject matter and related activity, as set forth in the curriculum guide, to be covered within 25 hours of classroom instruction time. These modules can be organized by the teacher in a sequence or unsequenced order for instructional content to be taught, within a specified subject area to form the course.

Acknowledging the constraints outlined in the curriculum guide for the teacher to follow, it is suggested that when the modules are organized they can be formatted into 3-credit or 5-credit courses. Schools have the option to select the modules within courses to meet the specific needs of the students. Schools are encouraged to select 3 modules for a 3-credit course and 5 modules for a 5-credit course. The variation in time available for a 3- or 5-credit course will require some adjustment as to how learning tasks are structured following the seven components of a module listed in Chapter One.

Computer Processing 10-20-30 has been modularized into 18 modules of content, one of which is identified as core and the other 17 as electives. The general objectives of these modules include the following:

> Become adept at the manipulation of hardware and software as preparation for career or personal use.
>
> Develop expertise in efficient programming techniques and program design.
>
> Recognize the impact of computers on productivity and career paths. (Alberta Education, 1985, p. 15)

These broad statements can be satisfied only when the students acquire certain knowledge, intellectual skills and abilities, attitudes, understandings, and psychomotor skills. These outcomes of learning receive their support and are consistent with the performance objectives established for each unit of instruction.

Rationale

Terms such as purpose, reason, introduction, "what and why" are interchangably used by curriculum authors to identify the rationale. Lewis (1971), explains the purpose of a rationale as a statement which, "should delineate what the Unit is about and why it is important for the student to learn this Unit" (p. 40). This author identifies two methods for writing the rationale as, the Terse Method and the Introductory Method. The Terse Method, is a brief and succinctly worded statement of purpose indicating what is to be learned and why the student should learn the content of the unit. The Introductory Method may consist of one or several comprehensive paragraphs which introduce the unit or module to the student. When the introductory method is used in a rationale it is often followed by a shorter comprehensive statement indicating the purpose of the unit. (pp. 62-68)

The development of a rationale for an item of instructional material is analogous to writing a justification. Meyen (1976), explains this as, "formulating a clear statement of the project goal, a description of the target population, and an identification of the assumptions underlying the curriculum development proposal" (p. 28). This author gives support to the position that the rationale must be couched in terms that communicate clearly and adequately the intent of the proposed curriculum. The emphasis should be on formulating a statement that is very clear and one that can be easily understood without further clarification by the individual writing the statement. (p 29)

Posner and Rudnitsky (1980), emphasize that in order for a course rationale to be useful and complete it should express a planner's values in terms of, "the learner, the society, and the subject matter" (p. 45). These authors identify the values of the learner as those conceptions of what individual learners are like and what they need. The assignment of societal values are those in respect to the society in which the learner lives. The third value is in respect to why the subject matter and the approach is significant enough to warrant a course, and of what value is that course to the learner. (pp. 44-49)

Objectives

Curriculum planners use the terms performance objectives or instructional objectives synonymously when identifying the expected outcomes of the units of instruction or lesson plans. Oliva (1982) explains the importance of instructional objectives, "the specification of instructional objectives simplifies the selection of instructional strategies and resources" (p. 354). Educational goals are statements of the outcomes of education, as Wiles and Bondi (1979), point out, "Goals are the basic elements in educational planning" (p. 227). The instructional goals and objectives are derived from the curriculum goals and objectives. Among curriculum authorities there is a commonly accepted philosophy, "that whatever the degree of congruence, there is a direct and natural progression from curriculum goals to instructional objectives" (Oliva, 1982, p. 356). To Oliva there is a difference between the two levels of goals and objectives, "The curriculum goals and objectives are broader in nature, aimed at all students as a group or groups, frequently jump across grade boundaries, often cut across disciplines, and many times are relevant to more than one teacher either within a discipline or among disciplines" (p. 355).

Instructional objectives tend to be more specific than curriculum goals and objectives. Hunkins (1980), states the difference between goals and instructional objectives, "Goals provide the teacher with broad and general statements of what they expect to accomplish in terms of student learning as a result of a particular course or total school year. . . . Extended further, goals evolve into program or course objectives" (p. 197).

Hunkins (1980), identifies four levels of objectives from program objectives to lesson objectives: "Program objectives can be called educational objectives or first level objectives. Unit objectives can be identified as instructional objectives or second level objectives. Lesson objectives can be called behavioral objectives or third level objectives. Objectives within a learning activity packet within a particular school lesson can be ranked as fourth level objectives" (p. 202).

The intended focus of this thesis is on the module with its general objectives stated in performance terms or fourth level objectives. These objectives are difficult to distinguish between instructional objectives or third level objectives because they represent a continuum from extreme generality to extreme specificity. According to Mager (1984), and others an instructional objective should be written in performance terms and should include these three characteristics, "performance, conditions, and criterion" (p. 21).

An objective is useful to the extent that it specifies what learners must be able to do or perform. For a learner to demonstrate mastery of an objective there must be circumstantial evidence of visible or audible human behavior. The ability to demonstrate overt or covert action (e.g., writing as opposed to adding) in measurable terms must be the bases of successful performance rather than an inference based on what people say. (Mager, 1984, pp. 23-25) Mager concludes, "Thus, the most important and indispensable characteristic of a useful objective is that it describes the kind of performance that will be accepted as evidence that the learner has mastered the objective" (p. 24).

A condition refers to the words describing the conditions or situation under which the selected behavior or performance is to occur. Enough descriptive conditions should be added to make an objective clear as to what is expected from the learner. Mager explains the conditions component when he states that a well written objective should, "Describe relevant or important conditions under which the performance is expected to occur" (p. 69). It is widely agreed amongst curriculum authors that as much description as is needed should be added to an objective so it clearly communicates the intent to others. Mager cautions that if the desired performance and the degree of excellence is clear then conditions should not be added arbitrarily to the objective statement. (pp. 49-69)

The criterion of an objective identifies for the learner how well they must be able to perform in order to complete the performance. Mager (1984), defines the criterion as, "the standard by which performance is evaluated, the yardstick by which achievement of the objective is assessed" (p. 71). Criterion is not only useful to the learner but can also be used to determine whether the instruction was successful. If the acceptable performance is specified then there is a standard against which to evaluate the learning outcomes. Mager lists three criteria used to specify acceptable performance in an objective; "time limits, accuracy, and quality" (p. 83). Each of these may be stated as a criterion within an objective to identify the requirements for successful achievement of the performance.

To conclude, Mager contends that an objective is useful if it can answer the following questions:

> What is the main intent of the objective?
> What does the learner have to do to demonstrate achievement of the objective?
> What will the learner have to do it with or to? And what, if anything, will the learner have to do without?
> How will we know when the performance is good enough to be considered acceptable? (p. 86)

Learning Activities

The instructional objectives specify the content of the lesson and identify how student behavior will change as a result of the student's participating in the lesson. Thus, the direction of the lesson has been determined, and the task is now one of designing learning activities that can be used to carry out its objectives. To Lewis (1971), learning activities are employed in order to provide a means whereby the instructional objectives can meet the varied needs, interests, and abilities of each student. (pp. 95-96) Meyen (1976), identified six conditions that should be addressed when selecting learning activities:

1. The selected activites must allow for the teaching of specified instructional objectives.
2. The activities must be commensurate with the abilities of the pupils.
3. Select activities which integrate with topics from core areas.
4. Keep the activities meaningful.
5. Plan for evaluation.
6. Plan for use of experience charts. (pp. 69-70)

Review of Related Research

Michigan Study

This research began in 1980 with an initial survey conducted jointly by The University of Michigan, referred to in this report as the Michigan Study, and the Society of Manufacturing Engineers (SME), on the future trends of industrial robot design, robot application, and their impact on society. Preliminary results from the survey were published in 1982 in, Industrial Robots: A Delphi Forecast of Markets and Technology. The forecasting process continued through the spring of 1985 and culminated in Industrial Robots Forecast and Trends, Delphi, second edition. (1985)

The research took three years to complete because of the time required to do a Delphi study. The Delphi forecasting method uses a procedure which invloves presenting a questionnaire to a panel of experts which is completed with written comments that support one individual's point of view. Statistical summaries of the questionnaire are identified and the questionnaire is redistributed to the panel. After several rounds of question repetition and refinement a consensus forecast is reached. The Delphi method was selected to collect data so that the final outcome was a set of results that represented the distilled knowledge of those invited to be part of the research group.

The research began when three panels of 60 to 100 persons were selected to conduct the Delphi which investigated future trends in robotic design, robot application, and the impact of robots on society. The panel members were taken from two sources: SME technical committee on robotics and major trade unions which represented workers from the manufacturing industries. All SME members were invited to submit questions for the first round questionnaires. (p. 2) This process generated 200 questions which were sorted according to subject matter. These questions were then edited, and mailed as three separate questionnaires, to those persons selected as panelists. "As responses to the three questionnaires were received, they were entered into their respective data bases. Three rounds of questionnaires were conducted" (pp. 2-3).

Data from the panel were summarized and reported using the median and interquartile range as standard statistical measures. The median is obtained by arranging all replies in a chronological list and selecting the middle value. The interquartile range is specified by the two extremes of the middle 50% of the same chronological list used to obtain the median. The forecast presentation is organized by subject matter and comparisons made within each of the specialized topic areas. To describe future events, sentences were revised from an interrogative form in the questionnaire to a declarative statement for the report. The following are some of the major findings of the study:

> Domestic sales of robots will reach 10,000 units annually by the end of the decade and 20,000 units by the end of the century. . . .
> The number of robots purchased in the U.S. is expected to increase throughout the decade in all manufacturing classifications, . . . particularly electronics and precision equipment producers . . . (8% 1985, 16% 1995) . . .
> Robot leasing and time-share programming services are projected to

> develop to . . . 15 % of all robots will be leased . . . 1995.
> The electronics industry is forecast to increase their use of applications robots to include 14% of unit sales in 1995. (p. 8)

The report continues by forecasting the manner in which the appearance and accuracy of a robot will change by 1995. It also predicts that there will be an abundant variety of robots available on the market. It is predicted by 1995, 15% of robots will have two or more arms, 21% will move along a track, that mini, micro, and mainframe computers will be the controlling devices that will direct the movements of 90% of all robots. Certain classes of robots will be accurate to plus or minus .0005 of an inch. (pp. 8-9)

The third dimension that this research considered was the societal impact that robots will have. It is evident that the overall displacement of workers by robots will be 4.3% by 1995. Approximately 90% of these displaced workers will remain with their employer at time of displacement and will receive lateral transfer, retraining, or promotion. Those who were not eligible will take either early retirement or will be terminated. The report continues by identifying the occupations that will be most effected by the installation of robots. These occupations include, "production painters (20% displacement), welders and flame cutters (20%), machinists and machine operators (13%), and assembly workers (10%). Line supervisory personnel are projected to decline by 3%" (p. 10). The retraining cost for these displaced workers will be the responsibility of private industry with the likelihood that both the state and local governments will offer some type of training program.

Doctoral Dissertations

A search was made of the Comprehensive Dissertation Index (CDI) from January 1982 through to February, 1988, to determine if any doctoral dissertations had been completed on the topic of robots and education. In conducting this search the following keywords were cross-referenced under the general subject heading, Education: robot, robots, and robotics. The result of this search was one research abstract of a study completed by Charles at the Universtiy of Northern Colorado. The title of that dissertation was, Comparisons Between Industry Requirements and Educational Program Offerings in Robotics Curriculum. The major purpose of that research was to determine what education and experiences were required by industry of their employees working in the field of robotics, and what curriculum offerings were available in four-year college and university industrial arts/technology education programs. One of the concluding recommendations from this study was, "The use of industrial robots was rapidly advancing, therefore, education's curricula should continually be updated from data gathered from industry." (Tutor, Dissertation Abstracts International Vol. 46 No. 08 February 1986, p.2211-A)

A physical search of the following reference sources was made: Canadiana, Directory of Education Studies in Canada, University of Alberta Education Theses and Selected Projects, and Master's Theses in Education. The benchmark for these searches was 1982, to the most recent listing that was available at the University of Alberta, Education Library. This search resulted in two theses being identified as having relevance to the current study. The authors, titles, and locations of the theses were:

> Dunlap (1987), Robotics Implementation in Industrial Arts Teacher Education Programs in The Contintental United States. Louisiana State University, Baton Rouge (70803).
>
> Hsiung (1987), Identification of Content and The Development of Laboratory Experiments Designed to Promote Robotic Literacy for Industrial Education Programs. University of North Dakota, Grand Forks (58201).

Unfortunately the time required to secure these theses through inter-library loans was too extensive to aquire these works using this library process.

ERIC

A search was completed of the Educational Resource Information Center (ERIC) data base using descriptors which are commonly associated with the term robotics and are listed in the ERIC Thesaurus. In the Thesaurus (1986) robotics is defined as the, "Study, design and use of robots, mechanical devices that can be programmed to perform tasks of manipulation and locomotion under automatic control" (p. 207). Associated with this definition were the following descriptors; Industrial Robotics, Robots, Automation, Bionics, Artificial Intelligence, Cybernetics, Electromechanical Technology, Electronic Control, Electronics, Industrial Arts, Man Machine Systems, Computer Uses in Education, Power Technology, Manufacturing Methods, Manufacturing Techniques, Computer Science Education, Educational Technology, and Computer Simulation. These were the descriptors used to search this data base for additional information.

As a result of using these descriptors individually, in combination, or by cross-referencing 121 hits were generated. A print-out for each included a document resume, author, publication, and a 150 word abstract for the researcher to evaluate. Of the 121 hits 25 were selected by the researcher for further analysis. From these 25 resumes 7 were selected as being related to this research. The seven were:

1. Auer, H. , North Dakota State Board for Vocational Education, 1985.
2. Ascension Parish School Board, Louisiana State Department of Education, November, 1984.
3. Arnold W. F. and Carpenter, C. J., Further Education Unit, London (England), July 1984.
4. Asfahl, C., University of Arkansas, April 1984.
5. Oregon State Department of Education, 1984.
6. Pittsburg State University, Kansas Vocational Curriculum

Dissemination Center, 1984.

7. Plymouth Board of Education, Connecticut State Department of Education, July, 1984.

How each of these had relevance to the current study is reported below.

Auer, H. (1985). Robotics : Instructional Manual

This instructional manual contains 20 learning activity packets designed to be used within a mobile robotics learning center. This project was sponsored by the University of North Dakota and the Department of Industrial Technology. Each learning activity packet contains information sheets, illustrations, and learning activities. A comprehensive list of 22 related robot topics on robotics range from safety considerations to the future of robotics. The material is at a level easily understood by high school students.

Ascension Parish School Board (1984). Robotics in Industrial Arts

Ascension Parish School Board in the state of Louisiana in 1984 established a pilot project which integrated a robotics module into its existing high school electronics classes. Students learned how the basic principles of electronics relate to robotics and had hands on experience with industrial robots. For this project, the instructor set up three robotic arms, three host microcomputers, and the necessary software to integrate the principles of electronics with units on robotics. Students were allowed hands on experience with both the educational robot arms and the computers. At the conclusion of the course students and staff rated the program very positively. A curriculum guide, robot information, student activities, and equipment inventories make up the majority of the report. This document includes the titles of seven units of instruction which are further broken down into sub-headings.

Arnold W. and Carpenter C. (1984). Robotic Arms. A Contribution to The Curriculum.

This report examines the problems of introducing technician courses for robotics at the college level in England. When the study was completed in 1984 the term "technician" was, "meant to include technically-trained staff other than professional engineers" (p. 7). From their research Arnold and Carpenter found there were three major problems of implementing a course in robotics. These were, "(a) the availability of suitable equipment at acceptable cost; (b) the lack of guidance on suitable teaching material; and (c) the training of teaching staff" (p. 7).

According to what these researchers reported the first of these needs was being met by an increased number of low-cost robotic arms. Although they acknowledged that the instructional material was available they found it dispersed over a wide range of different disciplines, "mechanical and electrical engineering, control, microprocessors and other topics" (p. 7). It was suggested by Arnold and Carpenter that teaching of introductory courses for robotics may be enhanced by integrating existing materials from a wide variety of disciplines. (p. 7)

To guide the development for a robotics core curriculum a comprehensive set performance objectives from which a selection could be made according to level of the course and background of the students. This bank of suggested objectives is supported by examples of course units which include: Evolution of Robotics; Robot Architecture; Power Drives and Actuators; Grippers and Manipulators; Control System Elements; Data Acquisition and Conversion; Microcoputer Control and Interfacing; Languages and Programming; Typical Arms and Applications; Robots As Systems Components; Current Developments; Practical Work; and Economics. (pp. 19-20)

Asfahl Dr. C. (1984). Curriculum Dilemmas for Robotics Educators

In this article Asfahl discusses methods of establishing meaningful curricula in robotics. This author cautions that robotics is a product of technology rather than a technology itself, he suggests that robotics should be incorporated within existing curricula. This authority identifies: design, operations, and maintenance as the three basic technical categories of robotics.

Oregon State Department of Education (1984). High School Industrial Arts. A Guide for Teachers.

This teacher's guide is an overview of the high school industrial arts program in Oregon State. The guide contained activities to assist teachers in developing a comprehensive course of studies related to technology and related careers. Included in the guide are the objectives, scope, and sequence of industrial arts. This is followed by a series of course outlines encompassing a variety of technological topics. One of these outlines suggests 3 major topics on robotics which is then further divided into various sub-topics.

Pittsburg State University (1984). Robot Service and Repair. Teacher's Guide.

Sponsored by Pittsburg State University and the Kansas Vocational Curriculum Dissemination Center this guide is designed to assist educators present a course on robot service and repair. The guide is organized into four units including: introduction to robots, power supply, robot control systems, and service and repair. Each unit contains several lesson plans, student activities, and teacher support materials. Much of the material presented would be relevant to a high school program.

Plymouth Board of Education (1984). A Secondary-Level Curriculum in Industrial Electronics and Robotics

This document describes a curriculum developed by a high school electronics teacher to provide the electro-mechanical skills necessary to operate and repair industrial robots. These materials were written for secondary and adult students within the State of Connecticut. The identified units were very comprehensive and developed to a level which would satisfy job-entry skills required of an electronics technician. Of the four courses one pertained directly to robotics. The course was comprised of seven main topics and then further subdivided into units associated to the topic.

Chapter III

Identifying Instructional Content

Introduction

The content of Chapter Two dealt with a review of the literature and research that was related to the current study. As a result of that review the procedure for organizing a module was identified and will form the framework for organizing and sequencing the instructional content for the teacher's module and its basic units of instruction in this study. The purpose of this chapter is to identify common instructional content that participants included in their course materials as well as the scope and sequence of these materials.

So that the reader will have a better understanding of the charting procedure (and the use of the results of charting) this chapter will be divided into two major sections. The first section will describe how charting is done to identify scope and sequence. The second section will place data from the chart into tabular form for analysis.

It will be recalled from chapter one that of the teachers recommended by their provincial or state supervisors 35 teachers were requested to participate in the investigation. When contacted through the mail only five teachers and two supervisors provided curriculum materials for analysis.

Course Materials Received

To identify the type of curriculum materials that were received from the research participants, table 1 was designed. Data in this table indicate that; two course guides, four course outlines, and one curriculum guide were received for analysis. These curriculum materials were sent by teachers in one Canadian province and six states. The majority of these states were from the northeast quadrant of the United States, the major manufacturing area of the country. It is evident from data in table 1 that two high school teachers, one technical instructor, one junior high school teacher and three supervisors for state departments of education provided the course materials that were requested. These data also indicate that robotics is not considered a junior high school subject but is taught as part of a senior high subject.

Table 1

Contributor and Type of Course Materials Received

School or Department	State or Province	Name of Contributor	Course Materials
Parkland Composite High School	Alberta	Booth G.	Course Outline
Blue Hills Regional Tech School	Massachusetts	Crowley J.	Course Outline
Department of Education	Minnesota	Ryerson T.	Course Guide
Oak Grove Jr. High	Minnesota	Barnes B.	Course Outline
Department of Education	Mississippi	Thomas M.	Curriculum Guide
Willard High School	Missouri	Talbot R.	Course Guide
State Education Dept.	New York	Stebbins C.	Course Outline

Charting

To identify the instructional units that research participants taught in their courses on robotics a charting procedure was employed. This procedure was used because it enhanced the systematic and a orderly method to identify both scope and sequence of the instructional content that was included in the course outlines, course guides, and curriculum guide that were received. Fryklund (1970), advocates for the instructional content of any skilled occupation to be identified the analyst should use of a chart with two axes, a horizontal axis and a vertical axis. On the horizontal axis of the chart, developed for this study, were placed the topics that were taken from the instructional materials submitted by participants. To make this listing more comprehensive additional topics were taken from introductory textbooks for robotics. The horizontal axis listed the topics on robotics under the following major categories: Introduction to Robotics; Robot Classification and Application; Robot Anatomy; Computer Control and Robot Performance; and Standards. These major catagories were then divided into subtopics. The vertical axis was divided into two categories: Topic and Name of Institution with a total column.

The intersection of these two axes formed a rectangle. When the curriculum material was analyzed for a particular school or agency the number one was placed in the formed rectangle of chart 1 which identified that, that particular topic was taught in a particular school. A copy of the chart can be found on page 66 and 67. In addition to identifying curriculum or course content this procedure helped to identify the scope of the curriculum materials that were received. Numbers in rectangles were totalled to show the number of participants who taught that particular topic or subtopics.

A decision was made by the researcher that any topic or subtopic with a score of four or less would be eliminated from the study. This decision was made as a result of time constraints. The most common topics were placed into the module until the alloted time was full. This procedure also established scope for the units of instructions for the initial draft of the robotics module.

Information obtained as a result of processing the data using the charting procedure was used to design tables for presentation of information. This procedure was followed so that these data could be easily analyzed and interpreted by the researcher as well as being easily understood by the reader.

Chart 1

Robot Topics Identified From Curriculum Materials Received

Topic	Name of Institution							
	Parkland Composite	Blue Hills Regional	Minnesota Dept of Ed	Oak Grove Jr. High	Mississippi Dept of Ed	Willard High School	New York State Ed Dept	Totals
Introduction to Robotics		1	1	1	1	1	1	6
Historical overview		1	1		1	1	1	5
Definition of related terms		1	1		1	1	1	5
Nomenclature	1	1			1	1	1	5
Robot Type		1	1		1	1	1	5
Social implications		1	1		1	1	1	5
Robot Anatomy	1	1	1		1	1	1	6
World Status		1	1		1	1	1	5
Robot Classifications		1	1		1	1	1	5
Geometry	1	1	1		1	1	1	6
Power Sources		1	1		1	1	1	5
Applications		1	1		1	1	1	5
Control Techniques		1	1		1	1	1	5
End Effectors		1	1	1	1	1	1	6
Interfacing			1			1	1	3
Robot Controllers		1	1		1	1	1	5
Sensors	1	[illegible]	1	1	1	1	1	7
Machine Vision		1	1		1	1	1	5
Artificial Intellegence		1	1		1	1	1	5
Mobility					1	1	1	3
Computer Control	1	1	1	1	1	1	1	7
Computer Technology	1	1	1	1	1		1	6
Computer Programming	1	1	1	1	1	1	1	7
Robot Programming	1	1	1		1	1	1	6
Robot Languages	1	1	1		1	1	1	6
Educational Robot	1	1	1	1	1	1	1	7
Overview	1		1	1	1	1	1	6

Chart 1 Continued

Topic	Name of Institution							
	Parkland Composite	Blue Hills Regional	Minnesota Dept of Ed	Oak Grove Jr. High	Mississippi Dept of Ed	Willard High School	New York State Ed Dept	Totals
Teach Pendant Programming	1	1	1	1	1	1	1	7
Off-line Programming	1	1	1	1	1	1	1	7
Robot Performance and Standards			1		1		1	3
Task Performance			1					1
Economic Performance			1					1
Performance Standards			1					1
Computer-Integrated Manufacturing			1	1	1			3
Flexible Manufacturing Syst.			1	1				2
CAD/CAM				1			1	2
Research and Development					1	1		2
Safety				1	1			2
Future Trends			1		1		1	3
Robot Physics			1			1		2
Hydraulics						1	1	2
Pneumatics						1	1	2
Electronics			1	1		1	1	4
Voice Synthesis	1						1	2
Human Comparison			1					1
Kinematics			1					1
Building a Robot		1		1		1	1	4

Chart 2

Commonality of Instructional Content of Curriculum Materials

Topic	Name of Institution							
	Parkland Composite	Blue Hills Regional	Minnesota Dept of Ed	Oak Grove Jr. High	Mississippi Dept of Ed	Willard High School	New York State Ed Dept	Total
Introduction to Robotics		1	1	1	1	1	1	6
Historical overview		1	1		1	1	1	5
Definition of related terms		1	1		1	1	1	5
Nomenclature	1	1			1	1	1	5
Robot Type		1	1		1	1	1	5
Social implications		1	1		1	1	1	5
Robot Anatomy	1	1	1		1	1	1	6
World Status		1	1		1	1	1	5
Robot Classifications		1	1		1	1	1	5
Geometry	1	1	1		1	1	1	6
Power Sources		1	1		1	1	1	5
Applications		1	1		1	1	1	5
Control Techniques		1	1		1	1	1	5
End Effectors		1	1	1	1	1	1	6
Robot Controllers		1	1		1	1	1	5
Sensors	1	1	1	1	1	1	1	7
Machine Vision		1	1		1	1	1	5
Computer Control	1	1	1	1	1	1	1	7
Computer Technology	1	1	1	1	1		1	6
Computer Programming	1	1	1	1	1	1	1	7
Artificial Intellegence		1	1		1	1	1	5
Robot Programming	1	1	1		1	1	1	6
Robot Languages	1	1	1		1	1	1	6
Educational Robot	1	1	1	1	1	1	1	7
Overview	1		1	1	1	1	1	6
Teach Pendant Programming	1	1	1	1	1	1	1	7
Off-line Programming	1	1	1	1	1	1	1	7

Of the 47 topics identified from the curriculum materials that were reviewed 20 received a score of 4 or less and were eliminated from the research. To determine commonality of this instructional content chart 2 was patterned after chart 1. All curriculum materials included a topic on the following; Sensors, Computer Programming, Teach Pendant Programming, Off-line Programming, the Educational Robot and Computer Control. The next most common type of instructional content included; An Introduction to Robots, Robot Anatomy, Robot Geometry, End Effectors, Computer Technology, Robot Programming, Robot Languages, and an Overview of the Educational Robot. Other common instructional content listed on the curriculum materials that were analyzed and are shown in chart 2, page 68, include; Historical Overview, Definition of Related Terms, Nomenclature, Robot Type, Social Implications, World Status, Robot Classifications, Power Sources, Applications, Control Techniques, Robot Controllers, Machine Vision, and Artificial Intelligence.

An analysis was made of the four course outlines, the two course guides, and the curriculum guide to determine if a rationale statement was included. The rationale statement had to explain to the student the reason or reasons why a particular lesson should be studied. To present data from this analysis table 2 was assembled. These data show that only three contributors included a rationale statement with their curriculum materials. Of these, two were departments of education and the third was a high school.

Table 2

Rationale Statement Listed

Contributor	Course Material	Rationale Yes	Rationale No
Parkland Composite High School	Course Outline		√
Blue Hills Regional Tech School	Course Outline		√
Department of Education	Course Guide		√
Oak Grove Jr. High	Course Outline		√
Department of Education	Curriculum Guide	√	
Willard High School	Course Guide	√	
State Education Dept.	Course Outline	√	

Table 3 was designed to determine the type of instructional objectives that participants included with their course materials. Data in this table shows that general objectives were the type of objectives used to describe the terminal behavior of a student who completed a particular unit. General objectives are considered to be level four objectives and are therefore not written with a criterion statement. These objectives give direction to the teacher to select learning activities, teaching strategies, and methods of evaluation. Data in table 3 indicate that the general objectives that were reviewed did not include criterion statements.

Table 3

Contributors and Type of Objective - Course Materials

Contributor	Type of Objective		Components		
	General	Instructional	Task	Condition	Criteria
Parkland Composite	√		√	√	
Blue Hills Regional					
Department of Ed.	√		√	√	
Oak Grove Jr. High					
Department of Ed.	√		√	√	
Willard High School	√		√	√	
State Education Dept.					

Table 4 was developed to identify the learning resources used by participants when teaching content for robotics. It was apparent from data in table 4 that with the exception of one participant all of the others used print material in the form of a text book, laboratory manual, or a hand-out to support their instruction. The majority of the participants made use of computers and educational robots for delivery of their course materials. From the material that the researcher analyzed it was found that three of the seven schools used films, filmstrips, or videotapes to assist teaching robotics. The majority of computer software that participants used was that needed to support programming languages, although some schools used application and computer assisted instruction software.

Table 4

Learning Resources Identified - Course Materials

Contributor	Print		Non Print				
	Text	Hand Out	Film	Film Strip	Video	Comp[1] Soft	Educ[2] Robot
Parkland Composite						√	√
Blue Hills Regional	√	√				√	√
Department of Ed	√	√		√	√		
Oak Grove Jr. High	√	√	√	√	√	√	√
Department of Ed	√	√				√	√
Willard High School	√	√	√			√	√
State Education Dept.	√	√				√	√

[1] Comp Soft = Computer Sofware
[2] Educ Robot = Educational Robot

To determine the learning activities participants used to present instructional content to the learner table 5 was prepared. In this table are data which show that all participants included some form of desk-work activities such as having the student write, read, or draw some part of the content that was taught. It is apparent from these data that fewer participants used the lecture method as a method of delivery and that they placed more emphasis on hands-on activities. Six of the seven participants indicated activities that involved programming an educational robot using both the teach pendant and the computer. Computer programming was identified as a popular learning activity, all but one participant indicated using a computer to develop computer software. Computer assisted instruction (CAI) and computer applications were used in three of the schools. CAI was used to introduce students to the computer and to perform robot arm simulations. Computer applications included computer assisted design (CAD) programs and telecommunication software.

Table 5

Learning Activities Identified - Course Materials

Contributor	Lect.[1]	Lab[2]	Desk Work	Comp[3] Appl.	CAI[4]	Comp[5] Prog.	Robot[6] Prog.
Parkland Composite			√	√		√	√
Blue Hills Regional	√		√			√	√
Department of Ed.	√		√				
Oak Grove Jr. High	√	√	√	√	√	√	√
Department of Ed.		√	√			√	√
Willard High School		√	√		√	√	√
State Education Dept.		√	√			√	√

[1] Lect = lecture
[2] Lab = laboratory activity
[3] Comp Appl. = Computer Applications
[4] CAI = Computer Assisted Instruction
[5] Comp Prog. = Computer Programming
[6] Robot Prog. = Educational Robot Programming

Chapter IV

Designing the Module on Robotics

Introduction

The previous chapter dealt with the charting procedures used to identify scope and sequence. The information from these charts was designed as tables for data analysis. Data from these charts were used to organize the preliminary draft of the suggested module and its units of instruction. According to leading authorities a module has a rationale, performance objectives, and learning activities

From the analysis of the charts, the tables, and the literature review the following seven unit titles were identified; Introduction to Robotics, Robot Classifications, End Effectors, Robot Controllers, Sensors, Computer Control, and Educational Robot.

The module on robotics and its supporting units of instruction were sent to the Panel of Experts for them to critically review, analyze, modify or change any of the content of the components of the units. How this Panel of Experts was selected and the selection criteria is described in chapter one.

After the module was returned to the researcher the comments made by members of the Panel were used to revise the preliminary draft of the suggested module and its units of instruction. Upon revision of the units the module then became the recommended module of this research.

SUGGESTED ROBOTICS MODULE

CONTENT OUTLINE

TOPIC **CONTENT**

1. Status
2. Prerequisites
3. Rationale
4. Purpose
5. Units of Instruction
    - Unit 1. Introduction to Robotics
    - Unit 2: Robot Classifications
    - Unit 3: End Effectors
    - Unit 4: Robot Controllers
    - Unit 5: Sensors
    - Unit 6: Computer Control
    - Unit 7: Educational Robots
6. Recommended Resources

MODULE 19: ROBOTICS

Status: Elective

Prerequisite: Modules 1 and 8

Rationale:

The content of the units of instruction for this module include the scope and sequence for an introduction to robotics that proceed from simple to complex. These units of instruction can be used by a teacher as content organizers from which to select instructional content to prepare lesson plans to be taught to students. Each unit includes a number of general objectives that can be easily converted to instructional objectives by the addition of a criterion statement.

Although this module fits into the optional category for Computer Processing 10-20-30 it has prerequisites and equipment requirements that should be given consideration. Included with the learning resources are suggested references that should be read by the teacher before presenting the content to the learner

These units of instruction have been designed to interface with other modules of Computer Processing 10-20-30 and can be taught within the 25 hours allocated to this part of the program by Alberta Education.

Purpose:

The major purpose of this module and its supporting units of instruction is to provide the teacher with content organizers that can be used to organize instructional content for lesson plans needed to teach the robotics module to students enrolled in Computer Processing 10-20-30.

Unit 1: Introduction to Robotics

After completing this unit the student will be able to:

1. Chart the historical development of Robots.
2. Define the term robot and terms associated with robotics.
3. Explain the differences between the various types of robots including, health and human service robots, educational robots, and industrial robots.
4. Describe the social issues centered around robotics.
5. List the major components of a robot.
6. Identify the countries which employ a significant number of robots in an industrial environment.

Recommended Learning Resources:

Text Books

Asimov I. & Frenkel K. (1985). Robots, machines in man's image. General Publishing Company Ltd.: Toronto.

Hoekstra R. (1986). Robotics and automated systems. South Western Publishing Co.: Cincinnnati, Ohio.

Rehg, J. (1985). Introduction to robotics a systems approach. Englewood Cliffs, New Jersey: Prentice-Hall Inc.

Audio Visual Material

Robot Revolution, (1984), Visual Education Center, 75 Horner Ave, Toronto, Ontario. M8Z 4X5

Film: 18 min.
Colour

Software

AppleWorks. (1984) Apple Computers Ltd.

Paintworks Plus. (1987). Styleware Co.

Suggested Learning Activities:

View the film Robot Revolution.

Discuss the social issues identified in the film.

Read and study: Hoekstra (1986), chapter 1, pages 1 to 7.

Answer questions 1 to 3, page 40.

Read and study: Asimov I. & Frenkel K. (1985), chapters 1, 2, 5, and 6.

Use an electronic spread sheet to develop a chronological chart of the origin of robots.

Use word processing software to develop a biographical sketch of Joseph Engelberger and George Devol.

Identify the following three types of robots and give an example of each; health and human service, educational, and industrial.

Use CAD software to draw a pie chart which depicts the robot population of Japan, United States, and West Germany.

Read and study: Rehg, J. (1985), chapter 1, pages 1 to 21

Answer questions 1 to 16, pages 20 and 21.

Unit 2: Robot Classifications

After completing this unit the student will be able to:

1. Sketch the three robot arm coordinate systems: rectilinear, cylindrical, and spherical.
2. Identify six axes of rotation on a jointed arm industrial robot.
3. Identify the three main power sources of an industrial robot.
4. List the two major industrial application categories of a robot (assembly & non-assembly) and give an example of each.
5. Describe the closed-loop and open-loop control techniques of an industrial robot.
6. Describe the following path control techniques of an industrial robot: point-to-point, controlled path, and continuous path.

Recommended Learning Resources:

Text Books

Asimov I. & Frenkel K. (1985). Robots, machines in man's image. General Publishing Company Ltd.: Toronto.

Engelberger, J. F. (1984). Robotics in practice. American Management Associations: United States of America.

Hoekstra R. (1986). Robotics and automated systems. South Western Publishing Co.: Cincinnnati, Ohio.

Rehg, J. (1985). Introduction to robotics a systems approach. Englewood Cliffs, New Jersey: Prentice-Hall Inc.

Audio Visual Material

Frontiers of Technology: Robots. (1984), National Geographic Society, Educational

Services, Department 88, Washington, D.C. 20036
Sound filmstrip: 16 min.
Colour

Robots in Welding and Painting. (1987), The Society of Manufacturing Engineers, Dearborn Michigan.
Sound videotape: 35 min.
Colour

Software

AppleWorks. (1984). Apple Computers Ltd.

Paintworks Plus. (1987). Syleware Co.

Suggested Learning Activities:

View the sound filmstrip Frontiers of Technology: Robots
- Discuss the robot arm coordinate systems and the robot applications identified in the filmstrip.

Read and study: Hoekstra (1986), chapter 1, pages 7 to 14.
- Answer questions 4 to 7, page 41.

Read and study: Rehg (1985), chapter 2, pages 25 to 39.

Read and study: Asimov (1985), chapter 4, pages 75 to 80.
- Use CAD software to draw the three robot arm coordinate systems and the jointed-spherical coordinate system. Include in your drawing the degrees of freedom and the six axes of rotation.

Read and study: Rehg (1985), chapter 2, pages 39 to 58.
- Answer questions 4 to 10, pages 58 and 59.

Read and study: Engelberger(1984), Part II, chapters 10 to 24.

View the videotape, Robots in Welding and Painting.

Discuss how robots increase productivity and quality.

Discuss why robots are used in applications that are tough and tiring for humans.

Read and study: Asimov (1985), chapter 3, pages 49 to 70.

Use data base software to establish eight application categories as fields and insert three examples of each as records.

Read and study: Hoekstra (1986), chapter 11.

Answer questions 1 to 12, pages 635 and 636.

Unit 3: End Effectors

After completing this unit the student will be able to:

1. Describe the relationship of the end effector to the robot arm and list five characteristics of an end effector.
2. Discuss the significance of gripper intelligence.
3. Describe the following gripper types; standard, vacuum, vacuum surfaces, vacuum suckers, magnetic, air pressure, and special purpose.
4. List five special-purpose tools for use with an end-effector.
5. Define compliance.
6. Describe the two methods used to achieve compliance.

Recommended Learning Resources:

Text Books

Asimov I. & Frenkel K. (1985). Robots, machines in man's image. General Publishing Company Ltd., Toronto.

Engelberger, J. F. (1984). Robotics in practice. American Management

Associations: United States of America.

Rehg, J. (1985). *Introduction to robotics a systems approach*. Englewood Cliffs, New Jersey: Prentice-Hall Inc.

Audio Visual Material

Ballet Robotique. (1985) International Telefilm Enterprises, 47 Vensley Ave. Toronto M6M 5A8. Produced by Pyramid Films

Film: 8 min.
Colour

Robots in Assembly and Packaging. (1987), The Society of Manufacturing Engineers, Dearborn Michigan.

Sound videotape: 45 min.
Colour

Software

The BASIC Programming Language

Suggested Learning Activities:

Read and study: Engelberger (1984), chapter 3.

View the film *Ballet Robotique*.

List and describe five end effectors used by the automotive industry in this film.

Read and study: Rehg (1985), chapter 3, pages 61 to 89.

Answer questions 1 to 15, pages 88 and 89.

Develop a computer program, based on a decision tree, which will select the best end-of-arm tooling for each record in the robot application data base. (Unit 2)

View the videotape, Robots in Assembly and Packaging.

Discuss how robots can perform assembly and packaging jobs.

Describe the end effectors used in the film.

Unit 4: Robot Controllers

After completing this unit the student will be able to:

1. Describe a servo control system.
2. Describe and give the purpose of reference frames.
3. Identify four internal controls and three external controls for non-servo control systems.
4. Define the following internal feedback devices for servo control systems; potentiometers, optical encoders, resolvers, and synchros.
5. Describe the following external control factors; path-control technique and programming language.
6. List the responsibilities of the central processing unit within the controller architecture.

Recommended Learning Resources:

Text Books

Asimov I. & Frenkel K. (1985). Robots, machines in man's image. General Publishing Company Ltd., Toronto.

Hoekstra R. (1986). Robotics and automated systems. South Western Publishing Co.: Cincinnnati, Ohio.

Rehg, J. (1985). Introduction to robotics a systems approach. Englewood Cliffs, New Jersey: Prentice-Hall Inc.

Audio Visual Material

Frontiers of Technology: Electronic Chips. (1984), National Geographic Society, Educational Services, Department 88, Washington, D.C. 20036
Sound filmstrip: 16 min.
Colour

Programmable Controllers. (1987). The Society of Manufacturing Engineers, Dearborn Michigan.
Sound videotape: 27 min.
Colour

Suggested Learning Activities:

Read and study: Asimov (1985), chapter 3, pages 71 to 74.
Read and study: Hoekstra (1986), chapter 1, pages 14 to 40.
    Answer questions 8 to 14, page 41.
Read and study Rehg (1985), chapter 4, pages 91 to 117.
    Answer questions 1 to 28, pages 116 and 117.
View the sound filmstip; Frontiers of Technology: Electronic Chips,
    Define the following; MPU, CPU, RAM and ROM.
View the videotape, Programmable Controllers.
    Discuss how PC's can perform process functions.
    Describe the four applications used in the film.

Unit 5: Sensors

After completing this unit the student will be able to:

1. Describe the general purpose of any machine sensor.
2. Identify six reasons why sensors are used in a work cell.
3. Describe the functions of the following two contact sensors; limit switches and artificial skin (tactile).
4. Describe the functions of the following two non-contact sensors; proximity sensors and photoelectric sensors.
5. Describe the purpose of a process sensor.
6. List and explain five tasks performed by a vision system.
7. List the four vision system components.
8. Explain how a vision system can carry out the following tasks; image measurement, image analysis, and image recognition.

Recommended Learning Resources:

Text Books

Asimov I. & Frenkel K. (1985). Robots, machines in man's image. General Publishing Company Ltd., Toronto.

Hoekstra R. (1986). Robotics and automated systems. South Western Publishing Co.: Cincinnnati, Ohio.

Rehg, J. (1985). Introduction to robotics a systems approach. Englewood Cliffs, New Jersey: Prentice-Hall Inc.

Audio Visual Material

Miniature Miracle. (1984), National Geographic Society, Educational Services,

Department 88, Washington, D.C. 20036
Film 55 min.
Colour

Machine Vision. (1988). The Society of Manufacturing Engineers, Dearborn Michigan.
Sound videotape: 50 min.
Colour

Software

AppleWorks. (1984). Apple Computers Ltd

Suggested Learning Activities:

Read and study: Asimov (1985), chapter 7.

View the film Miniature Miracle.

Identify the type of sensor used in each computer application demonstrated in the film.

Read and study Rehg (1985), chapter 5, pages 121 to 151.

Answer questions on;

page 162 questions 1 to 7.

page 163 questions 12 to 15, 22 and 23.

page 163 questions 28 to 33.

Use an electronic spread sheet to complete the table in Project 1 of Rehg (1985), page 164.

Read and study: Hoekstra (1986), chapter 10, pages 523 to 596.

Answer questions 1 to 21, pages 595 and 596.

View the videotape, Machine Vision.

Describe five examples of current machine vision applications.

Describe the three types of machine vision; binary, gray scale, and correlation.

Unit 6: Computer Control

After completing this unit the student will be able to:

1. Describe the following four system functions performed by the computer in high-technology robots; manipulation, sensing, intelligence, and data processing.
2. Identify three methods used to develop a robot language, and list two languages which were developed by each method.
3. Describe and rank the following four programming language categories; joint control, primitive motion, structured, and task-oriented.
4. Describe the advantages and disadvantages of programming languages at each level.

Recommended Learning Resources:

Text Books

Asimov I. & Frenkel K. (1985). Robots, machines in man's image. General Publishing Company Ltd., Toronto.

Hoekstra R. (1986). Robotics and automated systems. South Western Publishing Co.: Cincinnati, Ohio.

Rehg, J. (1985). Introduction to robotics a systems approach. Englewood Cliffs, New Jersey: Prentice-Hall Inc.

Audio Visual Material

Computer: Tool for the Future. (1984), National Geographic Society, Educational
Services, Department 88, Washington, D.C. 20036
Film: 23 min.
Colour

Software

The LOGO Programming Language

Suggested Learning Activities:

Read and study: Asimov (1985), pages 87 to 94.
View the film Computer: Tool for the Future.
Discuss the impact of computer-based technologies on society.
Read and study Rehg (1985), chapter 6, pages 167 to 173.
Answer questions 1 to 6, on page 184.
Read and study: Hoekstra (1986), chapter 8, pages 395 to 462.
Answer questions 1 to 15, page 462.
Develop a program using LOGO which simulates the movements of an industrial robot arm.

Unit 7: Educational Robots

After completing this unit the student will be able to:

1. Distinguish between an Industrial robot and an educational robot.
2. Identify the major components of the Rhino educational robot.
   2.1 Identify the major components of the Hero educational robot.
3. Program an educational robot using the teach pendant mode.

4. Program an educational robot using the off-line programming language.
5. Follow the correct procedures to avoid damage to the components of the robot.

Recommended Learning Resources:

Text

Asimov I. & Frenkel K. (1985). Robots, machines in man's image. General Publishing Company Ltd., Toronto.

Accompanying manuals for:

Hero 2000: Heath Company, Heathkit/Zenith Educational Systems, Department 025, Benton Harbor, MI. 49022

Rhino: Rhino Robots, Inc., 3402 N. Mattis Avenue, P.O. Box 4010, Champaign, IL. 61820

Audio Visual Material

The Robotic Revolution, (1986), National Geographic Society, Educational Services, Department 88, Washington, D.C. 20036

Film: 24 min.
Colour

Accompanying video for Hero 2000: Heath Company,
Heathkit/Zenith Educational Systems, Department 025, Benton Harbor, MI. 49022

VCR 18 min.

Accompanying software for:

Hero 2000: Heath Company, Heathkit/Zenith Educational Systems, Department 025, Benton Harbor, MI. 49022

Rhino Robot: Rhino Robots, Inc., 3402 N. Mattis Avenue, P.O. Box 4010, Champaign, IL. 61820

Educational Robots

Hero 2000: Heath Company, Heathkit/Zenith Educational Systems, Department 025, Benton Harbor, MI. 49022

Rhino: Rhino Robots, Inc., 3402 N. Mattis Avenue, P.O. Box 4010, Champaign, IL. 61820

Suggested Learning Activities:

Read and study: Asimov (1985), chapter 5.
    Develop a list of names used to identify personal, promotional, hobby, or educational robots.
View the film The Robotic Revolution.
    List the activities performed by the eductional robots.
Read and study the operation manual for the educational robot.
Develop, save, and execute a program using the teach pendant mode for an educational robot.
Develop, save, and execute a program using the off-line programming technique for an educational robot.

Recommended Resources

Books

Asimov I. & Frenkel K. (1985). Robots, machines in man's image. General Publishing Company Ltd., Toronto.

Engelberger, J. F. (1984). Robotics in practice. American Management Associations: United States of America

Hoekstra R. (1986). Robotics and automated systems. South Western Publishing Co.: Cincinnnati, Ohio.

Rehg, J. (1985). Introduction to robotics a systems approach. Englewood Cliffs, New Jersey: Prentice-Hall Inc.

Films and Videotapes

Ballet Robotique (1985), International Telefilm Enterprises, 47 Vensley Ave. Toronto M6M 5A8. Produced by Pyramid Films

Computer: Tool for the Future. (1984), National Geographic Society, Educational Services, Department 88, Washington, D.C. 20036

Miniature Miracle (1984), National Geographic Society, Educational Services, Department 88, Washington, D.C. 20036

Machine Vision. (1988), The Society of Manufacturing Engineers, Publication Sales, One SME Drive, P.O. Box 930, Dearborn, Michigan.

Programmable Controllers. (1987). The Society of Manufacturing Engineers, Publication Sales, One SME Drive, P.O. Box 930, Dearborn, Michigan.

Robots in Assembly and Packaging. (1987), The Society of Manufacturing Engineers, Publication Sales, One SME Drive, P.O. Box 930, Dearborn, Michigan.

Robots in Welding and Painting. (1987), The Society of Manufacturing Engineers, Publication Sales, One SME Drive, P.O. Box 930, Dearborn, Michigan.

Robot Revolution. (1984), Visual Education Center, 75 Horner Ave Toronto M8Z 4X5

The Robotic Revolution, (1986), National Geographic Society, Educational Services, Department 88, Washington, D.C. 20036

Sound Filmstrips

Frontiers of Technology: Electronic Chip. (1985), National Geographic Society, Educational Services, Department 88, Washington, D.C. 20036

Frontiers of Technology: Robots. (1985), National Geographic Society, Educational Services, Department 88, Washington, D.C. 20036

Software

AppleWorks. (1984). Apple Computers Ltd.

Paintworks Plus. (1987). Syleware Co.

Apple LOGO. (1984). A programming language.

Educational Robots

Hero: Heath Company, Heathkit/Zenith Educational Systems, Department 025,
Benton Harbor, MI. 49022

Rhino: Rhino Robots, Inc., 3402 N. Mattis Avenue, P.O. Box 4010,Champaign, IL.
61820

REVIEW OF THE SUGGESTED ROBOTICS MODULE BY THE PANEL OF EXPERTS

Selecting the Panel of Experts

It will be recalled from the first chapter that criteria were established for selecting the Panel of Experts. Ten educators who met these criteria were randomly selected from the 300 educators or industrial trainers listed in the Directory of the Robotics Education and Training Institutions, 1984-85. A covering letter (see Appendix C, page 151) was prepared and mailed to each individual member inviting them to become a member of the panel who would review the suggested robotics module. and its accompanying units of instruction. Included in the content of this letter was the date the panel was to return their reactions to the researcher. By that date only three members of the panel had fulfilled their obligation and returned the module with their comments. To increase the rate of return the remaining seven members of the Panel of Experts were contacted by telephone. From this contact an additional three members of the panel returned the module.

Of the six members who responded only one provided comments that were considered to be negative. This member indicated that some of the units of instruction were inappropriate for a course on robotics for senior high school and some of the learning resources should be deleted, particularly Asimov. This member was emphatic that the scope of the module should be changed to include more on physics, electrical systems and mechanical assemblage than, "fiction and romantic wishful thinking". (personal correspondence S. Thomas, p. 2)

The remaining five members of the Panel took a position that was diametrically the opposite. They felt that the module was relevant and significant for a high school student. Some of the comments made by these members to the researcher are listed below.

> I have no suggested changes, and feel that this course should generate interest in Robotics.
> (personal correspondence R. J. Podlasek, p. 1)

> I have reviewed your proposed robotics program, and it appears to be a well thought-out plan. The layout presents an even-flow curriculum.
> (personal correspondence Ron Bailey, p. 1)

> Your list of recommended Text Books seem to be an excellent choice . . . it looks like you have done an outstanding job of researching and finding the latest materials available for teachers to use.
> (personal correspondence Howard E. Pearsall, p. 1)

> After reviewing your draft of the Robotics Module, I find it to be an excellent learning module for high school students. . . . The recommended learning resources I find to be quite adequate for a fundamental background in the area of Robotics and Automation.
> (personal correspondence Harry Presley, p. 1)

> Overall, I am pleased with what you are proposing. I am particularly impressed with how you have integrated word processing, spreadsheet usage, and other computer applications into the study of robotics.
> (personal correspondence James E. LaPorte, p. 1)

In addition to the comments made by the Panel of Experts, minor recommended changes to the units of instruction were included. Members of the panel also recommended additional learning resources and learning activities. These recommendations were incorporated into the units of instruction of the module because of their relevancy for high school students. Changes were made to the content of the recommended module and can be identified by the italic typeface.

RECOMMENDED ROBOTICS MODULE

CONTENT OUTLINE

TOPIC **CONTENT**

1. Status
2. Prerequisites
3. Rationale
4. Purpose
5. Units of Instruction
    - Unit 1. Introduction to Robotics
    - Unit 2: Robot Classifications
    - Unit 3: End Effectors
    - Unit 4: Robot Controllers
    - Unit 5: Sensors
    - Unit 6: Computer Control
    - Unit 7: Educational Robots
6. Recommended Resources

MODULE 19: ROBOTICS

Status: Elective
Prerequisite: Modules 1 and 8

Rationale:

The content of the units of instruction for this module include the scope and sequence for an introduction to robotics that proceed from simple to complex. These units of instruction can be used by a teacher as content organizers from which to select instructional content to prepare lesson plans to be taught to students. Each unit includes a number of general objectives that can be easily converted to instructional objectives by the addition of a criterion statement.

Although this module fits into the optional category for Computer Processing 10-20-30 it has prerequisites and equipment requirements that should be given consideration. Included with the learning resources are suggested references that should be read by the teacher before presenting the content to the learner.

These units of instruction have been designed to interface with other modules of Computer Processing 10-20-30 and can be taught within the 25 hours allocated to this part of the program by Alberta Education.

Purpose:

The major purpose of this module and its supporting units of instruction is to provide the teacher with content organizers that can be used to organize instructional content for lesson plans needed to teach the robotics module to students enrolled in Computer Processing 10-20-30.

Unit 1: Introduction to Robotics

After completing this unit the student will be able to:

1. Chart the historical development of Robots.
2. Define the term robot and terms associated with robotics.
3. Explain the differences between the various types of robots including, health and human service robots, educational robots, and industrial robots.
4. Describe the social issues centered around robotics.
5. List the major components of a robot.
6. Identify the countries which employ a significant number of robots in an industrial environment.

Recommended Learning Resources:

Text Books

Asimov I. & Frenkel K. (1985). Robots, machines in man's image. General Publishing Company Ltd.: Toronto.

Hoekstra R. (1986). Robotics and automated systems. South Western Publishing Co.: Cincinnnati, Ohio.

Rehg, J. (1985). Introduction to robotics a systems approach. Englewood Cliffs, New Jersey: Prentice-Hall Inc.

Audio Visual Material

Robot Revolution, (1984), Visual Education Center, 75 Horner Ave Toronto M8Z 4X5

Film: 18 min.
Colour

Software

AppleWorks. (1984) Apple Computers Ltd.

Paintworks Plus. (1987). Styleware Co.

Suggested Learning Activities:

View the film Robot Revolution.
  Discuss the social issues identified in the film.
Read and study: Hoekstra (1986), chapter 1, pages 1 to 7.
  Answer questions 1 to 3, page 40.
Read and study: Asimov I. & Frenkel K. (1985), chapters 1, 2, 5, and 6.
  Use an electronic spread sheet to develop a chronological chart of the origin of robots.
  Use word processing software to develop a biographical sketch of Joseph Engelberger and George Devol.
  Identify the following three types of robots and give an example of each: health and human service, educational, and industrial.
  Use CAD software to draw a pie chart which depicts the robot population of Japan, United States, and West Germany.
Read and study: Rehg, J. (1985), chapter 1, pages 1 to 21.
  Answer questions 1 to 16, pages 20 and 21.

Unit 2: Robot Classifications

After completing this unit the student will be able to:

1. *Identify the three robot arm coordinate systems: rectilinear, cylindrical, and spherical.*
2. Identify six axes of rotation on a jointed arm industrial robot.
3. Identify the three main power sources of an industrial robot.
4. List the two major industrial application categories of a robot (assembly & non-assembly) and give an example of each.
5. Describe the closed-loop and open-loop control techniques of an industrial robot.
6. Describe the following path control techniques of an industrial robot: point-to-point, controlled path, and continuous path.

Recommended Learning Resources:

Text Books

Asimov I. & Frenkel K. (1985). Robots, machines in man's image. General Publishing Company Ltd.: Toronto.

Engelberger, J. F. (1984). Robotics in practice. American Management Associations: United States of America.

Hoekstra R. (1986). Robotics and automated systems. South Western Publishing Co.: Cincinnnati, Ohio.

Rehg, J. (1985). Introduction to robotics a systems approach. Englewood Cliffs, New Jersey: Prentice-Hall Inc.

Audio Visual Material

Frontiers of Technology: Robots. (1984), National Geographic Society, Educational

Services, Department 88, Washington, D.C. 20036
Sound filmstrip: 16 min.
Colour

Robots in Welding and Painting. (1987), The Society of Manufacturing Engineers, Dearborn Michigan.
Sound videotape: 35 min.
Colour

Software

AppleWorks. (1984). Apple Computers Ltd.

Paintworks Plus. (1987). Styleware Co.

Suggested Learning Activities:

View the sound filmstip Frontiers of Technology: Robots
Discuss the robot arm coordinate systems and the robot applications identified in the filmstrip.
Read and study: Hoekstra (1986), chapter 1, pages 7 to 14.
Answer questions 4 to 7, page 41.
Read and study: Rehg (1985), chapter 2, pages 25 to 39.
Read and study: Asimov (1985), chapter 4, pages 75 to 80.
Use CAD software to draw the three robot arm coordinate systems, including the six axis jointed-spherical coordinate system. Include in your drawing degrees of freedom and the axes of rotation.
Read and study: Rehg (1985), chapter 2, pages 39 to 58.
Answer questions 4 to 10, pages 58 and 59.
Read and study: Engelberger (1984), Part II, chapters 10 to 24.

View the videotape, Robots in Welding and Painting.

Discuss how robots increase productivity and quality.

Discuss why robots are used in applications that are tough and tiring for humans.

Read and study: Asimov (1985), chapter 3, pages 49 to 70.

Use data base software to establish eight application categories as fields and insert three examples of each as records.

Read and study: Hoekstra (1986), chapter 11, pages 599 to 637.

Answer questions 1 to 12, pages 635 and 636.

Unit 3: End Effectors

After completing this unit the student will be able to:

1. Describe the relationship of the end effector to the robot arm and list five characteristics of an end effector.
2. Discuss the significance of gripper intelligence.
3. Describe the following gripper types; standard, vacuum, vacuum surfaces, vacuum suckers, magnetic, air pressure, and special purpose.
4. List five special-purpose tools for use with an end-effector.
5. Define compliance.
6. Describe the two methods used to achieve compliance.

Recommended Learning Resources:

Text Books

Asimov I. & Frenkel K. (1985). Robots, machines in man's image. General Publishing Company Ltd., Toronto.

Engelberger, J. F. (1984). Robotics in practice. American Management

Associations: United States of America.

Rehg, J. (1985). Introduction to robotics a systems approach. Englewood Cliffs, New Jersey: Prentice-Hall Inc.

Audio Visual Material

Ballet Robotique. (1985) International Telefilm Enterprises, 47 Vensley Ave. Toronto M6M 5A8. Produced by Pyramid Films.
Film: 8 min.
Colour

Robots in Assembly and Packaging. (1987), The Society of Manufacturing Engineers, Dearborn Michigan.
Sound videotape: 45 min.
Colour

Software

AppleWorks. (1984). Apple Computers Ltd.

Suggested Learning Activities:

Read and study Engelberger (1984), chapter 3, pages 41 to 58.

View the film Ballet Robotique.

List and describe five end effectors used by the automotive industry in this film.

Read and study Rehg (1985), chapter 3, pages 61 to 89.

Answer questions 1 to 15, pages 88 and 89.

Insert a record into the robot application data base (Unit 2) which will *contain the most appropriate end-of-arm tooling for each example of the applications.*

View the videotape, Robots in Assembly and Packaging.

Discuss how robots can perform assembly and packaging jobs.

Describe the end effectors used in the film.

Unit 4: Robot Controllers

After completing this unit the student will be able to;

1. Describe a servo control system.
2. Describe and give the purpose of reference frames.
3. Identify four internal controls and three external controls for non-servo control systems.
4. Define the following internal feedback devices for servo control systems; potentiometers, optical encoders, resolvers, and synchros.
5. Describe the following external control factors; path-control technique and programming language.
6. List the responsibilities of the central processing unit within the controller architecture.
7. *Discuss the concept of a work cell environment.*

Recommended Learning Resources:

Text Books

Asimov I. & Frenkel K. (1985). Robots, machines in man's image. General Publishing Company Ltd., Toronto.

Hoekstra R. (1986). Robotics and automated systems. South Western Publishing Co.: Cincinnnati, Ohio.

Rehg, J. (1985). Introduction to robotics a systems approach. Englewood Cliffs, New Jersey: Prentice-Hall Inc.

Audio Visual Material

Frontiers of Technology: Electronic Chips. (1984), National Geographic Society, Educational Services, Department 88, Washington, D.C. 20036
Sound filmstrip: 16 min.
Colour

Programmable Controllers. (1987). The Society of Manufacturing Engineers, Dearborn Michigan.
Sound videotape: 27 min.
Colour

Computer Software

ROBCAT. (1987). C.A.T. COMPUTER APPLICATIONS TOMORROW, Carlsbad, California.
Colour graphics

Suggested Learning Activities:

Read and study: Asimov (1985), chapter 3, pages 71 to 74.
Read and study: Hoekstra (1986), chapter 1, pages 14 to 40.
  Answer questions 8 to 14, page 41.
Read and study Rehg (1985), chapter 4, pages 91 to 117.
  Answer questions 1 to 28, pages 116 and 117.
View the sound filmstip; Frontiers of Technology: Electronic Chips,

Define the following; MPU, CPU, RAM and ROM.

View the videotape, Programmable Controllers.

Discuss how PC's can perform process functions.

Describe the four applications used in the film.

Develop a program for each of the four applications identfied in the ROBCAT software.

Unit 5: Sensors

After completing this unit the student will be able to:

1. Describe the general purpose of any machine sensor.
2. Identify six reasons why sensors are used in a work cell.
3. *Describe the functions of the following two contact sensors; limit switches and tactile sensors (artificial skin).*
4. Describe the functions of the following two non-contact sensors; proximity sensors and photoelectric sensors.
5. Describe the purpose of a process sensor.
6. List and explain five tasks performed by a vision system.
7. List the four vision system components.
8. Explain how a vision system can carry out the following tasks; image measurement, image analysis, and image recognition.

Recommended Learning Resources:

Text Books

Asimov I. & Frenkel K. (1985). Robots, machines in man's image. General Publishing Company Ltd., Toronto.

Hoekstra R. (1986). Robotics and automated systems. South Western Publishing

Co.: Cincinnnati, Ohio.

Rehg, J. (1985). Introduction to robotics a systems approach. Englewood Cliffs, New Jersey: Prentice-Hall Inc.

Audio Visual Material

Miniature Miracle. (1984). National Geographic Society, Educational Services,
Department 88, Washington, D.C. 20036
Film 55 min.
Colour

Machine Vision. (1988). The Society of Manufacturing Engineers, Dearborn
Michigan.
Sound videotape: 50 min.
Colour

Software

AppleWorks. (1984). Apple Computers Ltd

Suggested Learning Activities:

Read and study: Asimov (1985), chapter 7, pages 165 to 201.

View the film Miniature Miracle.

Identify the type of sensor used in each computer application demonstrated in the film.

Read and study Rehg (1985), chapter 5, pages 121 to 151.

Answer questions on;

page 162 questions 1 to 7.

page 163 questions 12 to 15, 22 and 23.

page 163 questions 28 to 33.

Use an electronic spread sheet to complete the table in Project 1 of Rehg (1985), page 164.

Read and study: Hoekstra (1986), chapter 10, pages 523 to 596.

Answer questions 1 to 21, page 595 and 596.

View the videotape, Machine Vision.

Describe five examples of current machine vision applications.

Describe the three types of machine vision; binary, gray scale, and correlation.

Unit 6: Computer Control

After completing this unit the student will be able to:

1. Describe the following four system functio by the computer in high-technology robots; manipulation, sensing, intelligence, and data processing.
2. Identify three methods used to develop a robot language, and list two languages which were developed by each method.
3. Describe and rank the following four programming language categories; joint control, primitive motion, structured, and task-oriented.
4. Describe the advantages and disadvantages of programming languages at each level.

Recommended Learning Resources:

Text Books

Asimov I. & Frenkel K. (1985). Robots, machines in man's image. General Publishing Company Ltd., Toronto.

Hoekstra R. (1986). Robotics and automated systems. South Western Publishing Co.: Cincinnnati, Ohio.

Rehg, J. (1985). Introduction to robotics a systems approach. Englewood Cliffs, New Jersey: Prentice-Hall Inc.

Audio Visual Material

Computer: Tool for the Future. (1984), National Geographic Society, Educational Services, Department 88, Washington, D.C. 20036
Film: 23 min. Colour

Software

The LOGO Programming Language

Suggested Learning Activities:

Read and study: Asimov (1985), chapter 4, pages 87 to 94.
View the film Computer: Tool for the Future.
Discuss the impact of computer-based technologies on society.
Read and study Rehg (1985), chapter 6, pages 167 to 173.
Answer questions 1 to 6, on page 184.
Read and study: Hoekstra (1986), chapter 8, pages 395 to 462.
Answer questions 1 to 15, page 462.
Develop a program using LOGO which simulates the movements of an industrial robot arm.

Unit 7: Educational Robots

After completing this unit the student will be able to:

1. Distinguish between an Industrial robot and an educational robot.
2. Identify the major components of the Rhino educational robot.
    2.1 Identify the major components of the Hero educational robot.
3. Program an educational robot using the teach pendant mode.
4. Program an educational robot using the off-line programming language.
5. Follow the correct procedures to avoid damage to the components of the robot.

Recommended Learning Resources:

Text

Asimov I. & Frenkel K. (1985). Robots, machines in man's image. General Publishing Company Ltd., Toronto.

Accompanying manuals for:

Hero 2000: Heath Company, Heathkit/Zenith Educational Systems, Department 025, Benton Harbor, MI. 49022

Rhino: Rhino Robots, Inc., 3402 N. Mattis Avenue, P.O. Box 4010, Champaign, IL. 61820

Audio Visual Material

The Robotic Revolution, (1986), National Geographic Society, Educational Services, Department 88, Washington, D.C. 20036
Film: 24 min. Colour

Accompanying video for Hero 2000: Heath Company, Heathkit/Zenith Educational
Systems, Department 025, Benton Harbor, MI. 49022
VCR 18 min.
Colour

Accompanying software for:

Hero 2000: Heath Company, Heathkit/Zenith Educational Systems, Department
025, Benton Harbor, MI. 49022

Rhino Robot: Rhino Robots, Inc., 3402 N. Mattis Avenue, P.O. Box 4010,
Champaign, IL. 61820

Educational Robots

Hero 2000: Heath Company, Heathkit/Zenith Educational Systems, Department
025, Benton Harbor, MI. 49022

Rhino: Rhino Robots, Inc., 3402 N. Mattis Avenue, P.O. Box 4010, Champaign, IL.
61820

Suggested Learning Activities:

Read and study: Asimov (1985), chapter 5, pages 95 to 123.

  Develop a list of names used to identify personal, promotional, hobby, or educational robots.

View the film The Robotic Revolution.

  List the activities performed by the eductional robots.

Read and study the operation manual for the educational robot.

Develop, save, and execute a program using the teach pendant mode for an educational robot.

Develop, save, and execute a program using the off-line programming technique for an educational robot.

Recommended Resources

Books

Asimov I. & Frenkel K. (1985). Robots, machines in man's image. General Publishing Company Ltd., Toronto.

Engelberger, J. F. (1984). Robotics in practice. American Management Associations: United States of America

Hoekstra R. (1986). Robotics and automated systems. South Western Publishing Co.: Cincinnnati, Ohio.

Rehg, J. (1985). Introduction to robotics a systems approach. Englewood Cliffs, New Jersey: Prentice-Hall Inc.

Films and Videotapes

Ballet Robotique. (1985), International Telefilm Enterprises, 47 Vensley Ave. Toronto M6M 5A8. Produced by Pyramid Films

Computer: Tool for the Future. (1984), National Geographic Society, Educational Services, Department 88, Washington, D.C. 20036

Miniature Miracle (1984), National Geographic Society, Educational Services, Department 88, Washington, D.C. 20036

Machine Vision. (1988), The Society of Manufacturing Engineers, Publication Sales, One SME Drive, P.O. Box 930, Dearborn, Michigan.

Programmable Controllers. (1987). The Society of Manufacturing Engineers, Publication Sales, One SME Drive, P.O. Box 930, Dearborn, Michigan.

Robots in Assembly and Packaging. (1987), The Society of Manufacturing Engineers, Publication Sales, One SME Drive, P.O. Box 930, Dearborn, Michigan.

Robots in Welding and Painting. (1987), The Society of Manufacturing Engineers, Publication Sales, One SME Drive, P.O. Box 930, Dearborn, Michigan.

Robot Revolution. (1984), Visual Education Center, 75 Horner Ave Toronto M8Z 4X5

The Robotic Revolution, (1986), National Geographic Society, Educational Services, Department 88, Washington, D.C. 20036

Sound Filmstrips

Frontiers of Technology: Electronic Chip. (1985), National Geographic Society, Educational Services, Department 88, Washington, D.C. 20036

Frontiers of Technology: Robots. (1985), National Geographic Society, Educational Services, Department 88, Washington, D.C. 20036

Software

Apple LOGO. (1984). A programming language.

- or equivalent programming software appropriate for sight hardware.

AppleWorks. (1984). Apple Computers Ltd.

- or equivalent integrated software appropriate for sight hardware.

BASIC. (1984). Apple Computers Ltd.

- or equivalent programming language appropriate for sight hardware.

Paintworks Plus. (1987). Syleware Co.

- or equivalent CAD or Paint software appropriate for sight hardware.

ROBCAT. (1987). C.A.T. COMPUTER APPLICATIONS TOMORROW, Carlsbad, California.

- or equivalent simulation software.

Educational Robots

Hero: Heath Company, Heathkit/Zenith Educational Systems, Department 025, Benton Harbor, MI. 49022

- or equivalent mobile robot.

Rhino: Rhino Robots, Inc., 3402 N. Mattis Avenue, P.O. Box 4010,Champaign, IL. 61820

- or equivalent industrial arm.

Chapter V

Summary, Findings, Observations and Recommendations

Introduction

Industrial robots were first introduced into the industrial environment in North America in 1961, since then robot technology has been implemented and the census of robots continues to grow. According to the University of Michigan (1985) study, by 1995 there will be approximately 90,000 application robots in industry. Closely allied to robot technology is computer technology. This is witnessed in the curriculum guide for Computer Processing 10-20-30 published by the Alberta Department of Education, when space was left for a module on robotics.

Summary

The major purpose of this study was to identify and organize the instructional content for the robot module. Supplementing the module were its related units of instruction. The module and its units of instruction were to be integrated into the elective strand for Computer Processing 10-20-30. It was not the purpose of this study to pilot test the recommended module that was developed. In support of the major purpose of the study there were four supporting objectives.

The first supporting objective was to identify the organizational structure that the module should have so that the instructional content of the units of instruction that comprise the module had relevancy, cohesion, and progress from the simple to the complex. A review of the literature indicated that many authors who have written on individualized or personalized instruction advocate that a module should contain the following components. A rationale statement which answers why the student should study and the teacher should teach this material. A performance objective written as general objectives to provide the teacher with direction for selecting, presenting and evaluating student achievement. Learning resources used to provide the teacher with background information in order to teach the unit of instruction. Learning activities which identify what the student should do in order to satisfy the general objective.

The second supporting objective was to determine if any Department of Education located in the United States or Canada with responsibility for secondary education had a curriculum or a portion of a curriculum which placed emphases on robotics. From correspondence with state and provincial supervisors for departments or ministries of education in the United States and Canada, 31 teachers were identified as teaching a portion of the curriculum which was directed at the topic of robotics.

The third supporting objective was to survey catalogs of major suppliers of educational robots as well as professional literature devoted to robotics to determine what "robot types" were available on the educational market. The information collected to satisfy this objective was used to prepare the learning activity component for the units of instruction of the module. It was evident from the review of catalogs and correspondence with suppliers of educational robots that a number of these manufacturers have discontinued manufacturing this type of robot. Why this has occurred cannot be documented and is open to conjecture.

The final supporting objective was to determine the availability of commercially prepared educational resources, both print and non-print, on the topic of robotics that could provide a support function for the units of instruction for high school teachers responsible for teaching Computer Processing 10-20-30. This information was used in organizing the units of instruction so that teachers would have this information readily available, to help clarify the learning tasks that they would teach to their students. The availability of commercially prepared educational resources for robotics in print and non-print form is difficult to locate. Much of the print material which is in the form of either a textbook or a laboratory manual is of university or college level and not written for the high school student. Non-print instructional materials such as films and videotapes fall into two catagories. They are either introductory to the field of robotics and are designed for the middle school student or are applications which are aimed at the business managerial level. There is an obvious gap between these materials and a need for material that is better suited for high school students.

Population and Sample

The research designed for the study called for three discrete populations to be used. The first of these populations was the supervisory group for Industrial Education from both Canada and the United States. This population was identified from the, Directory of Federal and State Officials listed in the September issue of School Shop (1987). The second population included those school teachers identified by supervisory personnel as teachers of robotics. The third population comprised the Panel of Experts and was taken from, The Directory of Robotics Education and Training Institutions, 1984-85, published by the Society for Manufacturing Engineers. This population was stratified into two groups; industrial trainers and tertiary educators who taught a course in robotics.

Research Methodology

A letter was sent to the industrial education supervisors throughout North America. Of the 65 letters that were sent 31 supervisors responded. This represented a rate of response of 47.7 %. A follow-up procedure was initiated, to increase the rate of response, which yielded an additional 10 responses or a total rate of response of 62.3%. Of the 41 supervisors who responded 17 were able to provide the information that was requested. Teachers from both rural and urban areas were selected to be involved in the study. These teachers were sent a letter of request asking them to provide the researcher with any course materials they were using to teach units on robotics. Of the 35 letters that were mailed to teachers 11 responded. Six of these teachers had to be eliminated from the research because the materials they sent were considered inappropriate for the study or these teachers failed to honour the deadline given by the researcher. Two supervisors for state departments of education provided the course materials that were requested. Course materials that were received included four course outlines, two course guides, and one curriculum guide.

Related Research

To identify related research for this study an extensive search was undertaken. A letter requesting relevant information was sent to the Education and Training Division of Robotics International, a division of the Society of Manufacturing Engineers (RI/SME). This request resulted in the identification of the Michigan Study, which had a significant impact on the forecasted robot population for the industrial sector within the next decade.

To determine if any doctoral dissertations had been completed on the topic of robotics and education a physical search was made of the Comprehensive Dissertation Index (CDI) from January 1982 through to February, 1988. A further search of the reference sources of the Canadiana, Directory of Education Studies in Canada; the University of Alberta Education Theses and Selected Projects; and Master's Theses in Education was completed. This research demonstrated that there was limited research completed at the doctorate and masters level that was directed to the study of robotics in secondary education. Only one dissertation was identified.

A search was completed of the Educational Resource Information Center (ERIC) data base using descriptors which are commonly associated with the term robotics. As a result 121 hits were generated. From these 121 abstracts seven were selected as having relevance to this research. These seven were described in detail in Chapter two.

Charting

To assist the researcher in identifying instructional content for commonality, scope, and sequence a charting procedure was used. The chart was a two axis chart where cells were checked to indicate commonality. A cut-off point was established at a total score of four or less. Those topics which did not exceed the cut-off point were eliminated from the research.

Findings

The research methodology previously described generated these findings.

The curriculum materials were received from supervisory personnel at the department of education level and on-line teachers from secondary schools in the United States and in Canada. Six out of seven participants identified 47 topics or sub-topics on robots which ranged from the social implications of robots to robot kinematics. Following the charting procedure only 20 of the 47 topics or sub-topics were considered to have commonality. These then became the topics and sub-topics to be integrated as units of instruction for the robotics module. It is evident from the curriculum materials received that four participants did not include a rationale statement in their course materials. To support this statement these data can be found on table 2, page 70. Although performance objectives are commonplace with curriculum materials, four of the participants included general objectives in the course materials that were received. These objectives did not include the criterion, which is considered by curriculum authorities as the major component for a performance objective.

Participants in the study used a wide variety of learning resources to teach the learner concepts related to robotics. Print materials were most often used followed by computer software and an educational robot. This could be partly attributed to the cost of non-print materials including, videotapes, computer software, and educational robots used to teach the concepts associated with robotics. Similarly there was a diversification of learning activities that were used to teach the concepts related to robotics. These included a wide variety of learning activities placed on a continuum from the lecture to computer programming. Least used were computer applications and computer assisted instruction. Supporting data can be found on table 5, page 73.

Observations

The following observations were made by the researcher while conducting this study and are specific to this study.

It was observed that the supervisors when contacted took an inordinate amount of time to respond to the letter inviting them to cooperate in the study. Some of these individuals took as long as three months to respond to the initial letter.

It was also observed that supervisors supplied names and addresses to the researcher of individuals who were not teaching a unit or a portion of a unit on robotics. It is possible that these supervisors may have been misinformed by some of the local supervisors of either Industrial Education or Computer Science as to what these teachers were actually doing.

A number of the teachers who were contacted informed the researcher they were not teaching robotics although their names had been listed. A related observation was that some of the teachers who were contacted did not wish to share their course materials with the researcher. This uncooperative attitude of teachers to share information could be partly attributed to the fact of the recency of robotics becoming part of the high school curriculum. Some of those teachers who did contact the researcher were teachers who were teaching electronics and/or computers who used robots as a means of enhancing their course content.

It was observed that the Society of Manufacturing Engineers and Robotics International were extremely cooperative and were freely willing to share any information they had that would assist the researcher in conducting the investigation.

The observation was made that one of the states in the sunbelt, Mississippi, provided the most comprehensive curriculum guide for robotics and other emerging computer based technologies such as, CAD/CAM, LASERS, Computer Numerical Control, Microcomputers, as well as, Pneumatics and Hydraulics.

Recommendations

The following recommendations are based on the findings and conclusions of this study.

The major finding of this study was that only 27 of the 47 topics and sub-topics identified received a rating higher than four. As a result of this finding it is recommended that these topics and sub-topics be integrated into the suggested module and be used by teachers who wish to pilot test these modules.

Recommendations to the Teacher

Another finding of the study was that a variety of learning resources were being used by participants. (see table 4, page 72) It is recommended that the teacher teaching the module on robotics use a variety of learning resources and teaching strategies to teach the concepts listed.

It is recommended because of the close relationship between robotics and the computer that the teacher make greater use of the computer and computer software so that students become aware of the interrelationship of these two technologies.

It is recommended that the teacher develop a rationale for each unit of instruction of Module 19: Robotics.

One of the findings of this study was that participants were placing less emphasis on the lecture as a means of delivering instructional content. It is recommended that a number of different learning activities be used with students who will be taught the content of Module 19. Among these should include not only lab work and desk-work using a variety of print materials but the use of computer application software, computer programming, and educational robot programming. Emphasis should be placed on using the technology to teach robot technology.

Recommendations to the Department of Education

The research design for this study was such that the module that was developed would not be pilot tested, therefore it is recommended to the Department of Education that this module be pilot tested in at least four high schools throughout the Province to determine its effectiveness.

Another recommendation to the Department of Education is that Module 19 become one of the elective modules for Computer Processing 10-20-30. Closely related to this recommendation is the recommendation that the teachers of

Computer Processing 10-20-30 be informed of the availability of Module 19.

In order to prepare teachers to teach the content of Module 19 it is recommended to the Department of Education that a robotics workshop be instituted as a recognized summer session course so that these teachers can develop the necessary competencies needed to teach the module on robotics.

It is evident from the review of the commercial literature that the cost of an educational robot can be exceedingly expensive for local school boards. It is recommended to the Department of Education that a cost shared funding program be established with participating school boards so that they may have the necessary funds to purchase an educational robot and related software. This would allow local school boards to purchase educational robots and educational support materials, so the learner can become robot literate.

Recommendations to the Faculty of Education, University of Alberta

The Faculty of Education has a responsibility for the pre-service preparation for secondary school teachers in the province. Part of the 40 courses that comprise the Bachelor of Education degree is one on computers in education. It is recommended to the department responsible for teaching this course to students enrolled in the secondary education program that Module 19 be integrated into the microcomputer course entitled, Introduction to Microcomputers in Education.

Recommendations for Further Research

It is recommended that this study be extended. The design of the study would call for the researcher to make site visits to selected schools to observe the robotics program being taught. This would permit the researcher the privilege of reviewing course content as well as support instructional materials and determine how they are correlated with that content.

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APPENDIX A

In this appendix can be found a copy of the initial letter of request which was sent to 65 state and provincial supervisors.

Included as part of this appendix is a list of the names and addresses of the state and provincial supervisors who were contacted through the mail.

Also included is a copy of the follow-up letter which was sent to those supervisors who did not respond to the initial letter.

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Department of Industrial and Vocational Education
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November 16, 1987

Copy of the letter sent to State and Provincial Supervisors.

Dear

In addition to teaching Computer Scienc[illegible]igh school with the Edmonton Public School Board I am also enrolled as a graduate student in the Faculty of Graduate Studies and Research at the University of Alberta. Part of the requirements for the masters degree is the completion of a thesis. For my research I have elected to develop a module on Robot/Automation that would be relevant for Grade 10, 11 or 12 students, and that could be integrated into the Computer Science Curriculum.

I am requesting your co-operation in the research by providing me with a list of any high school teachers in your jurisdiction who may be providing leadership in the teaching of robotics. These teachers could be teaching a full course, or units of instruction within a course, that concentrate on robotics. After receiving your list, I would like to correspond with these teachers to request a copy of their course material. Upon completion of my thesis, I will forward copies of my results to those teachers who participated.

I look forward to your response. Thank you for your assistance.

Sincerely yours,

Ray Cimolini,
Graduate student
c/o DR. C. H. Preitz
Supervisor

List of Names and Addresses of the State and Provincial Supervisors

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January 18, 1988

Copy of the follow-up letter sent to State and Provincial Supervisors.

Dear

Approximately two months ago I wrote to you requesting your cooperation in a research study I am conducting which is directed at the development of modules on robotics for senior high school students.

My records show that you have not responded to my initial request which was for you to provide me with a list of any high school teachers in your jurisdiction who may be providing leadership in the teaching of robotics.

The research design calls for me to contact these teachers asking them to supply me with a copy of their course materials.

A majority of the supervisors contacted have provided the information requested. I would like to include your name among those who participated in the study. When the study is completed a copy of the sample module will be sent to those who participate.

For the research to adhere to its established timeline I will need the information from you no later than February 19, 1988.

I look forward to your response. Thank you for your assistance.

Sincerely yours,

Ray Cimolini,
Graduate student
c/o DR. C. H. Preitz
Supervisor

APPENDIX B

Included in this appendix is a list of the names and addresses of 35 teachers from information that was received from state and provincial supervisors listed in Appendix A.

A copy of the letter of request which was sent to each teacher participant is also included in this appendix.

List of Names and Addresses of Teachers Identified by State and Provincial Superintendents

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Canada

Landry Mr. Gene
Carencro High School
721 West Butcher Switch Road
Lafayette, Louisiana
United States 70507

Lautt Mr. Ray
Edmonton School District No. 7
Edmonton, Alberta
Canada

McCreary Mr. George
Vinita High School
P.O. Box 408
Vinita, Oklahoma
United States 74301

Mills Mr.
B. C. Silver Junior High School
Theakston Road
Halifax, Nova Scotia
Canada B3R 1R8

Mix Mr. Kenny
Belaire High School
12121 Tams Drive
Baton Rouge, Louisiana
United States 70114

Moore Mr. Bart
O. Perry Walker High School
2832 General Meyer Avenue
New Orleans, Louisiana
United States 70114

Nagy Mr. Joseph
Thomas A. Edison High School
625 Summer Street
Elizabeth, New Jersey
United States 07201

Naidoo Mr.
M.S. NWT Department of Education
P.O. Box 1320
Yellowknife, Northwest Territories
Canada X1A 2L9

Neden Mr. Mike
Pittsburg Middle School
14th & Broadway
Pittsburg, Kansas
United States 66762

Newman Dr. Robert
Ocean County Vocational Technical School
Old Freehold Road
Toms River, New Jersey
United States 08753

Noel Mr. Edward
Capital Area Vocational Center
R.F.D. #2, Box 1070
Augusta, Maine
United States 04330

O'Hara Mr. James
Camden County Vocational Technical School
Crosskeys-Berlin Road
Berlin, New Jersey
United States 08081

Olynyk Mr. John
Victoria Composite High School
10210-108 Ave.
Edmonton, Alta.
Canada T5H 1A8

Pelletier Mr. Roger
Van Buren High School
321 Main St.
Van Buren, Maine
United States 04785

Rehg Mr. James
Trident Technical College
P.O. Box 10307
Charleston, South Carolina
United States 29411

Romanczak Mr. Gerry
J.V. Clark School
Box 38
Mayo, Yukon
Canada Y0B 1M0

Roth Mr. David
McClure North High School
705 Waterford Drive
Florissant, Missouri
United States 63033

Stevens Mr. Douglas
Red Rocks Community College
12600 W. 6 Avenue
Golden, Colorado
United States 80401

Talbot Mr. Roger
Willard High School
P.O. Box 98
Willard, Missouri
United States 65781

Trogdon Mr. Tim
Hickman High School
1104 North Providence
Columbia, Missouri
United States 65203

Van Horn Mr. Dennis
Lincoln Public Schools
720 South 22nd Street
Lincoln, Nebraska
United States 68510

Van Kooy Mr. Hank
Bergen County Vocational Technical School
200 Hackensack Avenue
Hackensack, New Jersey
United States 07601

Weeraseker Mr. Gamini
University of Southwestern Louisiana
USL Drawer 41008
Lafayette, Louisiana
United States 70504

Wilson Mr. Jim
Francis Tuttle Area Vo-Tech Center
12777 North Rockwell
Oklahoma City, Oklahoma
United States 73142

Zimmerman Mr. Bill
Ferriday High School
801 E.E. Wallace Boulevard
Ferriday, Louisiana
United States 71334

University of Alberta
Edmonton

Department of Industrial and Vocational Education
Faculty of Education

Canada T6G 2G5

633 Education Building South Telephone (403) 432-3678

January 22, 1988

Facsimile of the letter sent to 35 teachers.

Dear

In addition to teaching Computer Science in a high school with the Edmonton Public School Board I am also enrolled as a graduate student in the Faculty of Graduate Studies and Research at the University of Alberta. Part of the requirements for the masters degree is the completion of a thesis. For my research I have elected to develop a module on Robot/Automation that would be relevant for Grade 10, 11 or 12 students, and that could be integrated into the Computer Science Curriculum.

Your name has been forwarded to me by *(Teacher Contact Supervisor)* in response to my request to identify any high school teachers in your state who may be providing leadership in the teaching of robotics.

If you are teaching a full course, or units of instruction within a course, that concentrate on robotics, I would appreciate a copy of your course material. It would be appreciated if I could have your course material no later than February 26 so I can adhere to the research timeline. Upon completion of my thesis, I will forward copies of my results to you.

I look forward to your response. Thank you for your assistance.

Sincerely yours,

Ray Cimolini,
Graduate student
c/o DR. C. H. Preitz
Supervisor

APPENDIX C

Ten educators were invited to serve as members of the Panel of Experts, a list of the names and addresses of each member can be found in this appendix.

A letter inviting the educators to serve as members of the Panel of Experts and requesting the member to recommend changes to the suggested module and its units of instruction is also included in this appendix.

The Names and Addresses of
The Panel of Experts

Ron Bailey
Dyersburg State Community College
P.O. Box 648
Dyersburg, Tennessee
38025-0648

Robert L. Briggs
Ohlone College
43600 Mission Blvd.
Fremont, California
94539

John B. Burke
Bergen Community College
400 Paramus Road
Paramus New Jersey
07652

Ralph D. Clark
Clayton Junior College
P.O. Box 285
Morrow, Georgia
30260

James E. LaPorte
Virginia Tech
144 Smyth Hall
Blacksburg, Virginia
24061

Howard E. Pearsall
Polk Community College
999 Ave. H. NE
Winter Haven, Florida
33880

Robert J. Podlasek
Bradley University
111 Jobst Hall
Peoria, Illinois
61625

Harry Presley
Itawamba Junior College
653 Eason Blvd.
Tupelo, Mississippi
38801

Pat John Rosato
Unimation-Westinghouse
Shelter Rock Lane
Danbury, Connecticut
06810

Stan S. Thomas
New Jersey Institute of Technology
Dep't of Industrial & Management Engineering
Newark, New Jersey
07102

University of Alberta
Edmonton
Canada T6G 2G5

Department of Industrial and Vocational Education
Faculty of Education
633 Education Building South, Telephone (403) 432-3678

April 5, 1988

Copy of the letter sent to the Panel of Experts.

Dear

In addition to teaching Computer Science in a high school with the Edmonton Public School Board I am also enrolled as a graduate student in the Faculty of Graduate Studies and Research at the University of Alberta. Part of the requirements for the masters degree is the completion of a thesis. For my research I have elected to develop a module on Robot/Automation that would be relevant for Grade 10, 11 or 12 students, and that could be integrated into the Computer Science Curriculum.

This module and its units of instruction have been organized as suggested content organizers by the researcher. The research design prescribes that the module be reviewed by a Panel of Experts for scope, sequence, and relevancy.

Through the cooperation of RI/SME Education and Training Division "Educators Network" and because you have responsiblity for teaching a course in robotics at the tertiary level you have been selected as a member of the Panel of Experts. Therefore, I would like to invite you to become involved in the research by serving as a member of this Panel and analyze the enclosed module and its units of instruction on robotics.

In your review of the suggested module please feel free to make any changes or modifications you feel would add to the relevancy and significance of the module for a high school student to develop an awareness of robotics.

University of Alberta
Edmonton

Canada T6G 2G5

Department of Industrial and Vocational Education
Faculty of Education

633 Education Building South, Telephone (403) 432-3678

From the results of the review of the Panel the module and its units of instruction will be revised and modified using the recommendations and criticisms that are received. The revised module will then become the Recommended Module and its Units of Instruction for Computer Processing 10-20-30 resulting from the research.

It would be appreciated if I could receive your reactions to the module no later than April 30th in order to adhere to the research timeline. For those who cooperate in this portion of the investigation a copy of the Recommended Module and its Units of Instruction will be made available upon request.

Sincerely yours,

Ray Cimolini,
Graduate student
c/o DR. C. H. Preitz
Supervisor

APPENDIX D

A request was made to the librarian of The Alberta Teachers' Association to carry out a library search for any relevant or related literature to this study. In this appendix can be found a copy of the responding letter from the librarian at The Alberta Teachers' Association to the researcher.

Also included is a copy of the letter mailed to the Society of Manufacturing Engineers requesting their assistance with this research by identifying any relevant or related materials.

The Alberta Teachers' Association
11010 142 Street, Edmonton, Alberta T5N 2R1

1988 03 22

Mr Ray Cimolini
Queen Elizabeth Composite High School
9525 132 Avenue
Edmonton, Alberta
T5E 0Y4

Dear Ray

I have checked as many sources as possible re Robotics curriculum. Specifically there is nothing in the following:

Directory of Education Studies in Canada, 1983-1984
1987 index of Report on Education Research
Handbook of Research on Teaching, 3rd edition 1986
Teachers' Almanac, 1986-87
Education Almanac, 1987-88

You mentioned that you had already consulted ERIC; therefore, I checked only Education Index and Canadian Education Index. The attached articles are all that I located through CEI. I have enclosed a sample page from EI (July 86 to June 87 issue). I did not pull any of these articles because I was not sure which of these overlapped with ERIC information. I could do further research for you or you could consult these indexes at the University Education Library or, I believe, these are available on-line at the Alberta Education Library. I have also enclosed two pages from the State Education Journal Index. These are from US state equivalents of our ATA Magazine. We do not have these particular periodicals in our library, so I have enclosed the addresses for you.

Generally, it would appear your work has not been done before. Good luck with it.

Sincerely

Elaine

Elaine Atwood
Librarian

eaa/mg
Enc

453-2411 in Edmonton, 263-4774 from Calgary, 1-800-232-7208 from elsewhere in Alberta

University of Alberta
Edmonton

Department of Industrial and Vocational Education
Faculty of Education

Canada T6G 2G5

633 Education Building South Telephone (403) 432-3678

May 15, 1987

Alice L. Ciccu
ROBOTICS INTERNATIONAL
SOCIETY OF MANUFACTURING ENGINEERS
ONE SME DRIVE
P.O. BOX 930
DEARBORN, MICHIGAN
48121 U.S.A.

Dear Alice :

Hello and greetings from Western Canada. My name is Ray Cimolini and I am presently serving as treasurer for the SOCIETY OF MANUFACTURING ENGINEERS, EDMONTON AND NORTHERN ALBERTA CHAPTER.

I became a member of Robotics International three years ago because of a personal interest in robotics. Presently, I am conducting research for the faculty of Graduate Studies at the University of Alberta. This research will lead to the development of a Robot/Automation course at the secondary education level in the province of Alberta.

The first step toward the development of this course is to identify major companies throughout the United States and Canada which employ a large number of robots. It would be greatly appreciated if you could send me any information which would help to identify the top ten companies, including their names, addresses, and number of robots in operation (according to robot population).

I would like to become involved in the RI/SME EDUCATORS NETWORK and would you please forward a copy of the brochure "Education and Career Opportunities in Robotics/Automated Systems". I received a copy of the "Sample Curriculum Guide for Robotics/Automated Systems Technicians", via Bob Ankrapp. Please extend my greetings and gratitued to him the next time you talk with him.

Would you also send any information on how I may obtain a copy of the proceedings for this years "Robotics in Education" conference.

If you are aware or become informed of any further information which might be related to my area of interest please keep me informed.

Thank you for your all your assistance and efforts.

Sincerely,

Mr. Ray Cimolini
5517 145A Ave
Edmonton, Alberta
Canada T5A 2S2

VITA

Name: Ray A. Cimolini

Birth: January 10, 1954; Fernie, British Columbia

Education:

1988, University of Alberta, M.Ed.

1984, Morehead State University, Kentucky.
International Robotics Certificate.

1979, Teacher Certification: Alberta
Permanent Professional Certificate.

1978, University of Alberta, B.Ed.

Positions:

Teacher: Edmonton Public School Board, Queen Elizabeth Composite High School, 1986-89;

Consultant: Edmonton Public School Board Centre for Education, Microcomputer Services, 1985-86;

Teacher: Edmonton Public School Board Steele Heights Junior High, 1978-85;

Instructor: The Canadian National Institute for the Blind, Summer Teen Program, 1980.

Memberships:

Alberta Teachers Association Computer Council;

Alberta Teachers Association Industrial Education Council;

Robotics International Society of Manufacturing Engineers.